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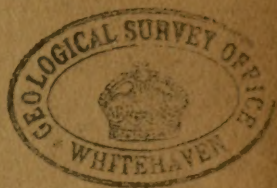
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SPECIAL REPORTS ON THE MINERAL
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VOL. XIV.—REFRACTORY MATERIALS: FIRECLAYS.

RESOURCES AND GEOLOGY.



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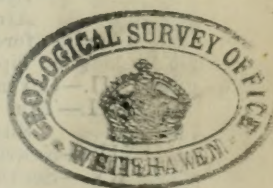
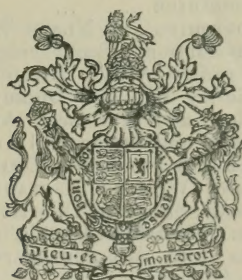
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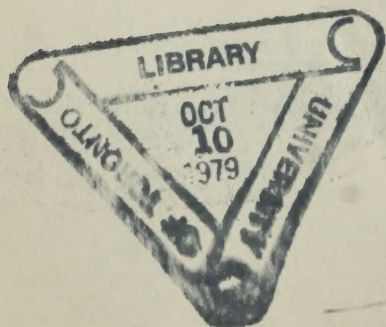
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PREFACE BY THE DIRECTOR.

This volume, the 14th of the 'Special Reports,' is the second of that series devoted to the subject of refractory materials. The 6th volume dealt with ganister and other forms of siliceous rocks, and with dolomite; the present volume continues the subject with an account of the fireclays which are so valuable a feature in the Carboniferous rocks and some other formations in Britain. In both volumes the account is confined to the resources of the materials and to the geological conditions under which they are found. The chemical analyses now in hand, and the standard tests undertaken for the Geological Survey by Dr. J. W. Mellor in the Pottery Laboratory, will form the subject of another volume.

The field work necessary to bring our information on refractory materials up to date was carried out in 1916. Yorkshire was examined by Dr. Gibson; South Wales (part), South Staffordshire (part), Worcestershire (part), East Cheshire and South-East Lancashire (part), by Mr. Cantrill; Durham (part), Northumberland, south and east Derbyshire and adjoining parts of Leicestershire by Mr. Wedd; Durham (part), Yorkshire (part) and Warwickshire by Dr. Sherlock; south-west and part of the south-east of Lancashire, Coalbrookdale, South Staffordshire (part), Worcestershire (part) and South Wales (part) by Mr. Dewey; North Wales, Cumberland, Lancashire (Blackburn and Burnley district) and Ingleton by Mr. Smith; South Wales (part) and Devon (part) by Mr. Pringle; Derbyshire (Peak district), Cornwall and Devon (part) by Mr. Howe.

In Scotland the field work was carried out by Mr. L. W. Hinxman, and Mr. M. Macgregor, with contributions by Mr. G. V. Wilson on occurrences in Ayrshire, and from the late Dr. C. T. Clough.

The editing of the contributions furnished by the various authors has been entrusted to Mr. Howe. In performing this duty he has followed the same general arrangement of material that he adopted in Vol. VI. After the introductory chapter the remainder of the book deals with the occurrences in geographical order under the heads of counties.

The investigations of fireclays were carried out simultaneously with those of the refractory materials described in Vol. VI. In the preface to that volume acknowledgment was made of the assistance we had received from the numerous firms and individuals we had approached. The expressions of indebtedness apply equally to the present work.

A. STRAHAN,
Director.

Geological Survey Office,
25, Jermyn Street,
London, S.W. 1.
18th March, 1919.

CHAPTER 1.

INTRODUCTION.

Material for a comprehensive account of the Fireclays of Great Britain does not yet exist. The location and characters of certain important fireclays are matters of common knowledge; but information respecting very many clays is so imperfect that much work is required before we can say what are our resources in clays of definite quality.

This volume is to be regarded as a first step towards a full description of the British Fireclay resources. It gathers together for the first time the *geological* data respecting the known fireclay deposits, it indicates also, in certain areas, the potential sources of supply. The next step must be the preparation of standardised tests and analyses of the clays. This work is already in hand, but in present circumstances its progress is necessarily slow.

In the following pages the geological occurrences are described by districts. Much inequality will be observed, due in part to the desire to avoid repetition in cases where great uniformity characterises the fireclay over a considerable area, and in part to the difficulty in drawing a line between good fireclays employed for higher refractory purposes and others, good of their kind, used only for sanitary ware or for less refractory purposes. Further, there are areas in which the only fireclays known are of comparatively low grade.

No classification of British fireclays, except the simple geological one has been attempted here. When sufficient data are available some sort of classification will be undertaken.

The geological classification has its uses; Coal Measure fireclays have certain characteristics in common and they are sharply marked off from the decomposed granite, the pocket deposits, the Jurassic and Tertiary fireclays, and so on. The geological classification is of great assistance in the investigation of potential supplies. But beyond this it is of little assistance for the practical application of the clays. The changes that take place laterally in most beds of fireclay demand careful trial of the clay before its suitability can be assured.

Great Britain is wonderfully rich in fireclays, thanks to the great development of the Carboniferous rocks, and the greater part of the fireclays extracted, and most of those of the first grade, come from the Coal Measures and Millstone Grit Series.

The following table summarises the broad lines of geological distribution of the fireclays :—

Geological Distribution of Fireclays in Great Britain.

POCKET DEPOSITS of uncertain age (Post-Triassic).

TERTIARY	...	Oligocene, Basin deposits	Devonshire
		Eocene, Woolwich, and	Surrey.
		Reading Beds.	
CRETACEOUS	...	Wealden, Fairlight Clays	Sussex.
JURASSIC	...	Great Oolite, Upper	Rutland and Lincolnshire.
		Estuarine Series.	
CARBONIFEROUS		Coal Measures—	
		Upper Coal Measures	Lancashire, Warwickshire, North Staffordshire.
		Middle Coal Measures	Cumberland, Lancashire, Cheshire, Northumberland, Durham, Derbyshire, Leicestershire, North Staffordshire, South Staffordshire, Shropshire, Warwickshire, North Wales.
		Lower Coal Measures	Lancashire, Durham, Northumberland, Yorkshire, North Staffordshire, South and North Wales, Central Valley of Scotland, Ayrshire.
		Millstone Grit	...
			Lancashire, Cheshire, Forest of Dean, Central Valley of Scotland, Ayrshire.
		Calciferous Sandstone	...
		Series.	Renfrewshire.
IGNEOUS	...	Granite (decomposed)	...
			Cornwall, Devon.

Potential Sources and Reserves.—The problem of the future supply of fireclay in Great Britain may be limited at the outset to the consideration of those of high refractory quality or those possessing properties necessary for special manufactures; there is more than enough low grade and medium grade fireclay readily accessible for all time.

The great storehouse of better class fireclay is no doubt in the Coal Measures; with the aid of the geological maps and mine records it is easy to see that there are great reserves of the known high grade clays in each of the important areas in Yorkshire, South Staffordshire and Worcestershire, the Central Valley of Scotland, also in North and South Wales. There are also in each of the coalfields numbers of fireclays whose economic value is quite unknown. The Geological Survey will in future endeavour to classify these clays according to their probable utility. For this purpose, samples of fireclay obtained in trial borings and mine development should be submitted at once for examination.

The question of reserves and potential sources of fireclay is complicated by financial considerations. Many of the deep-seated Coal Measure clays would be unworkable by themselves on account of the cost, unless the adjoining coal seams could be worked at the same time. In numerous cases fireclay is extracted only as a by-product to the coal; it would not pay to work the clay alone.

In certain areas, notably in South Staffordshire and Worcestershire, the reserves of high-grade clay are dependent upon the unwatering of the mining area. A large addition to the reserves would accrue if a combined scheme of unwatering could be adopted.

In the Millstone Grit Series very little is known of the properties of the shales and fireclays over large areas, and much useful information would be obtained by a systematic sampling of the outcrops. The recent development of the bauxitic clays in Ayrshire is a case in point.

Of the other formations the reserves are comparatively unimportant unless other methods of manufacture are adopted. In the Stamford district there is no doubt a large quantity of material similar to that being exploited, but owing to the rapid variation in the character of the beds the amount available cannot be ascertained without direct trial.

The Fairlight clays about Hastings might yield a considerable mass of material possibly suitable for coke-oven bricks.

An entirely different class of raw material is provided by the decomposed granite areas of Cornwall and Devon, and good bricks have been made from it for many years. The reserves are large.

CHAPTER II.

CUMBERLAND.

Up to the present time, comparatively few of the fireclays of the Cumberland coalfield have been worked for refractory purposes. In the absence of any detailed account of the measures intervening between the coal-seams set out in the accompanying table (p. 6), the determination of the positions of the clays¹ in the geological sequence, and the task of correlation, have been attended by considerable difficulty.

The highest seam of fireclay obtained in this coalfield is that underlying the Fireclay Band coal in the Flimby district, and now worked at Seaton Moor Pit, and formerly at St. Helens and Moorhouse Guards. At the latter place it is called the Black Metal Band and occurs above a thin coal-seam with an underclay that has also been worked. In the direction of Flimby the clay is thought to deteriorate in quality.

From its position, $4\frac{1}{2}$ fathoms above the Lickbank seam, the fireclay worked at Camerton appears to be the same as the Little Main or Ganister seam, $6\frac{1}{3}$ fathoms above the Lickbank, worked at Gillhead, where the higher Clifton Little Main appears to be out.

The Micklam Fireclay coal, as proved in the bottom of Harrington No. 10 Shaft, occurs about 115 ft. below the Six-Quarters Seam and about 130 ft. above the Four-Foot. Since the latter figure is practically 43 yards, and the 43 Yards Coal is shown on the Geological map as cropping out in the sea-cliff near Harrington No. 5 or Micklam Pit, it is probable that the 43 Yards seam is the Micklam Fireclay seam. The seam has been proved in an underground borehole $1\frac{1}{2}$ miles north of Harrington No. 10 Pit, and also in a borehole at Moss Bay, Workington, and corresponds with the Three-Quarters seam at Flimby and St. Helens, and the Low Main of Camerton (beneath the Lickbank) in the area north of the Derwent.

Farther south a coal proved in a borehole near the main shaft of the Wellington Pit, Whitehaven, at a depth of about 119 ft. below the Six-Quarters seam, appears to correspond with the Micklam seam. It is shown at a depth of 956 ft. 4 ins. in a section of the Wellington Pit.²

¹ In determining the positions of some of the fireclays we have received valuable assistance from the late Mr. R. W. Cochrane, M.I.M.E., of the Whitehaven Castle Estate.

² Vertical Sections (*Geol. Survey*), Sheet 68, 1883.

The exact positions of the three or four seams worked at Wythemoor Colliery, situated $3\frac{1}{2}$ miles north-east of Micklam, are uncertain. If, however, we assume that the lower seam is correctly identified with the Four-Foot, the overlying Two-Foot coal, and its worked fireclay, is probably identical with the Micklam Fireclay seam. The top seam will then represent either the Six-Quarters seam of Whitehaven and Harrington, or one of the unnamed seams that occur between the Six-Quarters and the Micklam seams at Harrington Colliery. This implies a thickening of about 80 ft. in the strata between the Four Foot and the Micklam seams at Wythemoor, over the average thickness of these beds in the district between Whitehaven and Harrington.

The distribution of this seam would, therefore, seem to be extensive, although its quality is variable.

At Branthwaite the position of the fireclay is obscure: we might note, however, that the associated measures closely resemble those associated with the so-called Four-Foot seam at Wythemoor.

Further details will be found in the descriptions to follow.

The positions of the chief fireclays worked at different localities and of their corresponding coal-seams, are given in the table on the following page:—

Fireclays worked for the manufacture of fire-resisting goods in the Cumberland Coalfield. (New Ser. Ordnance Sheets 22 and 23).

Chief Coal-seams in the Middle and Lower Coal Measures ¹ from the Fireclay Band Coal downwards.	Seaton Moor.	Moorhouse Guards.	St. Helens.	Whitehaven.	Oatlands.	Gillhead.	Camerton.	Micklam.	Wythemoor.	Branthwaite.
Fireclay Band Coal ...	—	—	—
Little Seam (or Cannel)	—
White Metal Band	—
Little Coal (Upper Yard) Seam
Slaty Band
Ten-Quarters Seam
Rattler Band
Bannock Band	— p	—	...	...	...	...	...
Main Band or Cannel Coal
Yard Band
Clifton Little Main Coal
Fireclay Seam (Little Main or Ganister Seam)	—	—
Six-Quarters Seam
Lickbank Coal
55-yards Workington-Hamilton Seam or Wythemoor Parrot Coal
43-yards Coal	— p	...
Four-Foot Coal
Yewdale Coal
Millstone Grit

¹ Cf. Section on One-inch Geological Map, Sheet 101 S.W.

In Cumberland the fireclays are usually mined from shafts; but in one or two cases from day-eyes or drifts.

As a rule the clays are prepared weathered, chiefly because they are thereby rendered plastic. In a few instances it is said to rid the clay of alkalies and free it from nodules of ironstone. The demand for clay at the time of this inquiry was, however, so great, that much of it was used raw, and this entails longer milling.

The clay is usually first ground in a perforated dry pan, the fine dust being sieved off for cement or for dusting moulds, and then transferred to a solid-bottomed wet-pan in which grog is added. Some clay is pugged. Grog consists of broken bricks, but in some cases crushed Millstone Grit or silica-brick is also added.

As a rule firebricks, coke-oven bricks, furnace lumps, etc., are hand-made, but hydraulic or steam-driven machines are employed for making articles such as honeycomb bricks for Cowper stoves, tuyeres and sleeves. Stay-bricks and some by-product coke-oven bricks are also pressed. Stoppers, nozzles, etc., are hand-pressed.

In this district the drying floors are usually heated by fires.



Fig. 1.—Map of the Cumberland Coalfield.

There are no bags in the kilns, hence the flame discolours and glazes the goods stacked near the door and at the top of the pile. The flue is at the back of the kiln. The round beehive kiln is only occasionally used for firebricks in Cumberland.

The temperature of firing cannot be stated definitely, because it is tested by sight and shrinkage. Of two firms using the same clay the firing temperature in one case was said to be 1800°C ! in the other it was said to be 1100°C .

Firing lasts from 7 to 10 days, and the shrinkage varies between $\frac{5}{8}$ in. to 1 in. per foot in the case of hand-made goods. In pressed bricks the shrinkage is naturally much less.

Most of the goods are made for iron and steel firms, and by-product coke-ovens in Lancashire and Cumberland. Furnace-linings, stove-bricks and coke-oven bricks, chequer and honey-comb bricks, flue covers, tuyeres for Bessemer steel ladles and pots for ultramarine are made by the larger producers.

Ground ganister is prepared by ordinary methods in fairly large quantities.

No gas retorts are now made in this district, and no silica-brick is produced.

WORKINGTON IRON AND STEEL CO., LTD.

Workington.

The Micklam Pit and Brickworks.

Location: Shaft and works situated on Mineral Line on cliff-top about 2 miles south of Harrington, and one mile north of Parton Station, L. and N.W. Railway.

Maps: One-inch New Ser. Ordnance 28; Old Ser. Geological 101 S.W.; six-inch Cumberland 61 S.W.

Latitude $54^{\circ} 36' 5''$. Longitude $3^{\circ} 34' 30''$.

Geological formation: Lower Coal Measures.

The fireclay seam occupies a position intermediate between the Six-Quarters Seam above and the Four-Foot seam below. At Harrington No. 10 Pit, situated about half-a-mile to the south, the distance from the Six-Quarters to the base of the seam of fireclay (not worked there) is about 115 ft., whilst that from the base of the fireclay to the base of the Four-Foot seam is 130 ft.; a total of 245 ft. in all.

Since the seam is practically 43 yards above the Four-Foot Coal, it is doubtless the same as the 43 Yards Seam, the outcrop of which is shown at Micklam on the six-inch Geological map.

At the Micklam Pit (Harrington No. 5) the Six-Quarters seam is out; the top of the pit shaft is at 241 ft. O.D., and the base of the fireclay is at 196 ft. O.D., whilst the Four-Foot Coal occurs at a depth of 60 yards from the surface.

Section of beds worked at Micklam Pit:—

					Ft.	In.
Blues [blue shale, etc.]	...	...	...	...	10-12	0
Micklam Fireclay coal	...	...	...	...	1	2
MICKLAM FIRECLAY...	...	...	...	...	2	0

Red building bricks are made from the 'Blaes.'

The beds dip at about 1 in 15 (4°) towards the east, and the fireclay seam crops out in the face of the sea-cliff. In the mine the ground is comparatively unfaulted, but the Micklam Fault—130 fathoms down west—forms the western boundary. This fault seems to die out beneath the sea to the north. Near the shaft at No. 10 Pit the dip is about 1 in 6 (10°) to the east.

In character the clay is nearly black and fairly uniform, with no ironstone balls, and little or no ganister. It has high silica percentage and remarkably low alumina.

Reserves: In this mine there is a good reserve of clay, but it is used as fast as extracted. The seam has been proved as far north as Moss Bay near Workington (p. 4). At Micklam it pays to work all the beds in the above section. If worked individually it might be at a loss.

Mode of Working: All the workings are pillar-and-stall, the coal being extracted for the Micklam boilers.

Treatment: The clay is used in its raw state and thus saves re-handling. If weathered it is easier on the mills; otherwise, weathering is thought to confer no advantage. It is run to the mills by a tramway and first ground dry under edge-runners in a perforated pan, and then in a solid-bottomed pan in which it is also tempered. Broken bricks are used for grog, and a definite proportion of Barfs Silica-stone (felspathic grit) also is added.

Note.—Similar goods are made from this Micklam Clay at the Harrington Harbour Brickworks, which are under the same management and situated close to the blast-furnaces. The works are small.

CAMERTON COLLIERY & BRICKWORKS COMPANY.

Workington.

Wood Drift and River Drift Mines and Camerton Brickworks.

Location: (1) Wood Drift, situated a little north of the Brickworks, which are a few hundred yards north of Camerton Station (Whitehaven and Cockermouth Line). (2) River Drift, on north bank of Derwent, about $\frac{1}{8}$ mile east of Brickworks.

Maps: One-inch New Ser. Ordnance 22; Old Ser. Geological 101 N.W.; six-inch Cumberland 54 N.W.

Wood Drift: Latitude $54^\circ 39' 50''$. Longitude $3^\circ 29' 10''$.

Geological formation: Middle Coal Measures. (Fireclay Seam).

At Camerton No. 1 Pit, situated on the site of the works, the Fireclay Seam was proved to occupy a position between the Clifton Little Main and the Lickbank coal-seams, some of the details being as follows:—

	Fms.
Part of Main Band and Cannel Coal	...
Measures	...
Yard Band	...
Measures	...
Clifton Little Main	...
Measures	...
Ganister Seam	...
Measures	...
FIRECLAY SEAM	...
Measures	...
Lickbank Seam	...
Measures	...
Low Main, Three Quarters, or Micklam Fireclay Seam	...

An average section of the Low Main Seam at Wood Drift is as follows :—

							Ft. Ins.
Hard freestone roof	...	...	...	...	...	...	—
Fireclay Seam ...	{ Coal	...	...	...	...	...	2 2
	{ Fireclay	...	...	...	...	...	1 2
	{ Ganister	...	...	...	8 in. to	...	1 0
Freestone floor	...	...	...	...	...	...	—

The Wood Drift (143 O.D.) and the more recently-opened River Drift (105 O.D.) are both driven along the seam of fireclay. Other coals are worked besides that of the Fireclay seam.

Three important faults are to be reckoned with, each of which runs approximately north and south. The first is a down-throw east of 50 fathoms, and is met with 400 yards west of No. 1 shaft. The second, 60 fathoms down east, is encountered 220 yards east of No. 1 shaft, and the third, 35 fathoms down west, occurs 500 yards farther east.

The Wood Drift mine is situated between the first and second faults, and River Drift between the second and third. In both mines the general dip is south-west at 1 in $7\frac{1}{2}$ (7° - 8°).

Both coal and fireclay are affected at intervals by 'nip-outs,' in which the coal and most of the clay are cut out by either a conglomeratic ganister or a freestone, according to whether the roof or the floor is thickened. A thin band of fireclay of inferior quality usually covers or underlies the conglomerate of the 'nip-out,' forming a link with the bed on each side. Occasionally the ganister is cut out whilst the fireclay persists.

The 'nip-outs' sometimes branch, but run generally north-west and south-east, and average about 22 yards in width.

The dark slaty-coloured fireclay contains plant-remains, but few or no ironstone-nodes, and burns rather white. The ganister is a light-grey rock, which grinds to a white powder; the best quality is said to contain 95% of silica.

Reserves: Only a small proportion of the 500 acres of clay in the property has been worked; about 8,000 tons was weathering in the surface tips, but the greater part of the fireclay used daily is freshly mined. The seam does not crop out at the surface, and is limited underground by the 'nip-outs' and large faults.

Mode of working: The workings are all longwall, the faces being short and slightly oblique to the strike of the beds. A new drift was being driven from the Wood Mine, through the second fault, to work the coals upon the east.

Treatment: The raw clay is mixed with some weathered clay, and ground first in a perforated dry pan, the fine dust being sieved off for cement, and then with broken brick in a wet pan.

Ganister is ground and mixed with an equal proportion of fireclay and sold as ganister compound.¹

Building-bricks are made from clay beneath the Potash or Lick-bank seam, and some 'seconds' fireclay also is used for this purpose.

¹ Special Reports Mineral Resources, vol. vi, Ganister, etc. (*Mem. Geol. Surv.*). Ed. 2, 1920, p. 93.

GILLHEAD COAL, FIREBRICK & GANISTER CO., LTD.

Flimby, Maryport.

*Gillhead Mine and Brickworks.**Location* : Situated 1 mile S.E. of Flimby.*Maps* : One-inch New Ser. Ordnance 22; Old Ser. Geological 101 N.W.; six-inch Cumberland 44 S.E.Latitude $54^{\circ} 40' 40''$. Longitude $3^{\circ} 30' 0''$.*Geological formation* : Middle Coal Measures.

The chief seam worked here is the Little or Ganister Main, which is apparently the same as the Fireclay seam of Camerton Colliery (p. 9). The Clifton Little Main seam is probably out. Some details of the shaft-section are as follows :—

			Thickness.		Depth from Surface.	
			Ft.	Ins.	Fms.	Ft. In.
Glacial drift and measures...	...	...	—	—	—	—
Top Sill Coal	...	...	—	—	22	1 2
„ fireclay	{ Thick sill	...	1	4	—	—
	{ Second Clay	...	4	0	—	—
Freestone and black-band	...	...	10	9	—	—
Little or Ganister Main Coal	...	...	2	0	25	1 3
„ „ „ FIRECLAY	...	...	2	0	—	—
„ „ „ „ with ironstone balls, 'seconds'	...	...	2	0	—	—
„ „ „ GANISTER, 3 ft. to	...	...	2	0	—	—
Measures resting upon the Lickbank Coal	...	...	35	3	32	0 6

The surface level of the shaft is approximately 282 ft. O.D.

The Lickbank Coal in the property is nearly exhausted. With the exception of a little sold for household purposes, all the coal raised is used at the brickyard.

Gillhead is separated from Seaton Moor Colliery by the large Maryport Fault (180 fathoms down east at Maryport), of which the surface-position beneath the glacial drift is about 600 yards east of the pit-head. Farther south this fault probably splits up into smaller faults traversing the Camerton Collieries. A fault with north-east and south-west trend and 40-50 fathom throw (? down north-west) comes to the surface near the road-junction, about 250 yards north-north-west of the works. A third fault is said to occur near the western boundary of the mine. The beds dip westward at about 1 in 7 (8°).

The best fireclay of the Little Main seam is dark and slickensided and contains an average number of plant remains. The lower part of the clay is not so good. 'Ganister' is of fairly constant occurrence, and is said to be best where the beds are at shallow depth (this applies also to the fireclay). It is white, hard, and without dark streaks, and never weathers down to a plastic material. Small quantities of a rather pale, but good clay occur in association with this rock.

The upper part of the Top Sill clay is not so good as the best Little Main clay, and little has been worked to date. It, however,

and also the second-grade Little Main clay, is claimed to be as good as the Micklam fireclay.

Reserves: In the area at present worked, the greater part of the Little Main clay has been exhausted, but pillars are still left on the western side of the mine. The chief reserve, consisting of about 40 acres of clay, lies to the north, in the angle between the above-mentioned Maryport and 40-50 fathom faults. Most of the Top Sill clay is untouched.

Mode of working: Workings are all pillar-and-stall, and the chief waste is from that part of the clay which contains ironstone-balls.

Treatment: Weathering is permitted only for one or two months, owing to the rapid depletion of the surface stock. The clay is preferred weathered, the effect being to rid it of ironstone and render it plastic. It is ground and tempered in the usual way, the fine dust being sieved off for cement. A little of the 'Seconds' or Top Sill clay is added to the best clay in fire-resisting goods, and brick-waste is used for grog in the proportion of about 5 per cent. The clay burns nearly white and the bricks are said to bear up well under consistent heat, but will not stand rapid chilling.

Ganister compound,¹ consisting of approximately 1 part of fire-clay to 3 of ground ganister, is made for use chiefly with tuyeres. The ganister is not made up into silica-brick, but siliceous fire-bricks (half and half) have been made.

The output is fairly large. At the time of our visit 3,000 sleeves a week, 4,000 tuyeres a month, and 60-80 tons of ganister compound a month were being made. Ordinary building bricks are made of Top Sill and 'Seconds' clay.

FLIMBY & BROUGHTON MOOR COAL & FIREBRICK CO., LTD.

Maryport.

Seaton Moor Mine & Broughton Moor Firebrick Works.

Location: Colliery situated $1\frac{1}{2}$ miles E.S.E. of Flimby Station (Whitehaven & Carlisle Railway). Brickworks at Broughton Moor, nearly 1 mile N.E. of the Colliery.

Maps: One-inch New Ser. Ordnance 22; Old Ser. Geological 101 N.W.; six-inch Cumberland 45 S.W.

Colliery: Latitude $54^{\circ} 40' 45''$. Longitude $3^{\circ} 29' 15''$.

Geological formation: Middle Coal Measures.

The seam worked here is the underclay of the Fireclay Band Coal,² which may be correlated with the Black Metal Band of Moorhouse Colliery and the Fireclay Band³ of St. Helens Colliery.

¹ Special Reports. Mineral Resources, vol. vi, Ganister, etc. (*Mem. Geol. Surv.*), Ed. 2, 1920, p. 94.

² Termed the Hamilton Coal by Mr. Lloyd Wilson.

³ See Note on p. 4.

Its position with respect to the seams lower in the sequence is shown in the following shaft-section at Seaton Moor Pit:—

		Thickness.		Depth.	
		Ft.	Ins.	Yds.	Ft. Ins.
Fireclay Band Seam	Coal, average 1 ft. 6 ins. ...	2	6	—	
	FIRECLAY, average 2 ft. 6 ins. ...	3	6	40	0 2
	" (SECONDS), average 2 ft. ...	4	0	—	
	Coal	3½		—	
	Ganister, average 2ft. 6 ins. ...	1	6	—	
White Metal Band	Coal	1	7	—	
	Metal	6		—	
	Coal	1	5	62	2 4
Upper Yard Seam (coal)		1	9	66	1 4
Slaty Band (slate and metal with coals)		4	4	74	2 5
Ten Quarters Seam (goaf)		—		88	0 8
Rattler Band (Rattler and metals with coals)		4	1	99	0 3

In a pit near the Coke Ovens, a mile farther south, the distance between the Fireclay and Ten Quarters Coals is 65 ft. 6 in.; there is, therefore, a great thickening of the measures in this direction.

The general dip of the beds is towards the west at about 1 in 9 (6°-7°), and the eastward rise from the shaft carries the fireclay to the surface (beneath 30 ft. of Glacial drift). The clay is thrown in again by a 20 fathom fault passing a little to the west of Standing Stones, near which place it was formerly worked in shallow excavations—hence the old Brick and Tile Works on this site and the present location of the works at Broughton Moor.

Some distance west of the shaft a fault, which trends in the direction of Maryport Harbour, where it has a throw of 180 fathoms down west, separates the Seaton Moor workings from those of Gillhead (p. 11), where lower seams are mined.

The clay is thickest near the shaft, but thins off both north and south, especially in the latter direction, in which the coal also is thin. The same clay is said to occur near Flimby, but as a second-class clay only; it has, however, not yet had a fair trial.

The best clay, which contains plant-remains, is rather pale-grey in tint, with a black top close beneath the coal. It burns buff. The lower clay, of second quality, is coarser and breaks up into larger lumps when mined. It contains ironstone in clustered patches of small rounded pellets, about the size of a pin's head. These occur low down in the seam, and may be avoided with care. Ganister occurs in pockets, and is rarely seen now; it was formerly mined, but proved too costly an operation to be continued.

Reserves: Fireclay sufficient to last for about 15 years, if used at the present rate, still remains in the pit, which is worked by pillar-and-stall. The roads are high and pillars numerous, especially near the outcrop on the east, where there is only 30 ft. of boulder-clay as cover, forming a weak roof. Small faults give little trouble, and there is practically no water. The only waste is the iron-bearing 'seconds' clay.

Mode of Treatment: At ordinary times the clay is weathered as long as possible, and before the war a stock of 4,000 tons was kept at the works, but this is now exhausted and the clay is used almost raw.

Old firebricks and some broken, unused silica-bricks (imported for local coke-ovens, are added for grog. Ordinary firebricks, furnace-blocks, etc., and some coke-oven bricks are hand-made, whilst other coke-oven bricks, stay-bricks, stoppers, nozzles, etc., are hand- or machine-pressed.

Before the war the output of the firm consisted of fireproof goods and glazed sanitary ware in the proportion of 5 to 2, but at the present time the proportion of the former has risen considerably.

The broken silica-bricks, mentioned above, are ground up with fireclay and used for pointing brickwork in by-product coke-ovens. Ground ganister was formerly made for lining converters at steel-works.

Finely-ground fireclay and a 'seconds' clay from another seam, obtained by brushing the roads in the mine, are used for sanitary ware. The Little Main fireclay from the Bertha Pit, belonging to the same company, is very oily, and is made up into building bricks after long weathering.

A surface shale dug at outcrop near the old brickworks at Standing Stones, if mixed with fireclay, makes a blue brick suitable for the floors of sulphate of ammonia houses (by-product plant).

The seam of fireclay worked at Seaton Moor Pit is apparently the same as the Black Metal Band fireclay, worked for firebricks until 1914, at Moorhouse Guards Colliery and Brick and Tile Works (situated 1 mile N. of Low Seaton, and little over $\frac{1}{2}$ mile S.E. of St. Helens Colliery, Lat. $54^{\circ} 40' 15''$, Long. $3^{\circ} 31' 0''$) and the Fireclay Band fireclay, worked for firebricks many years ago at St. Helens Colliery (situated about 1 mile S.W. of Flimby, Lat. $54^{\circ} 40' 35''$, Long. $3^{\circ} 31' 35''$).

At Moorhouse Guards the fireclay was 3 ft. 9 ins. in thickness in the shaft-section. The underlying Little Seam and White Metal Band Coals also were worked, and some of the Little Seam fireclay (2 ft. 6 ins.) raised.

At St. Helens the Fireclay Band Coal lies about 26 fathoms above the Ten Quarters Seam (*see* table p. 6 and Vertical Sections, Sheet 75, *Geol. Surv.* No. 14, 1886). The fireclay was from 18 to 24 ins. in thickness, and a little ganister was also present. The coal was extracted long ago, and the clay does not pay to work alone.

Fireclays occur beneath underlying seams, one of which is said to occur about 10 fathoms below the Fireclay Band, and consists of 1 ft. of coal, overlying 2 ft. of fireclay, on 3 ft. of ganister. This may be that of the White Metal Band. At much lower levels a second-class fireclay, with ironstone balls, is occasionally raised in brushing the roads beneath the Clifton Little Main Coal and thrown on the spoil bank.

MORESBY COLLIERY CO., LTD.

Whitehaven.

Oatlands Colliery, Distington.

Location: Situated close to Fairfield Station on the Distington and Rowrah Branch Line (Workington Junction Railway), at Oatlands, about 2 miles S.E. of Distington Station.

Maps: One-inch New Ser. Ordnance 28; Old Ser. Geological 101 S.W.; six-inch Cumberland 61 S.E.

Latitude $54^{\circ} 34' 50''$. Longitude $3^{\circ} 30' 40''$.

Geological formation: Middle Coal Measures.

Although several coal-seams are worked at the colliery, the only fireclay raised is that in the Bannock Band Coal. The shaft is sunk in barren ground and the fireclay is got from two areas lying

respectively beneath Whillimoor Foot Farm (west of the railway) and Tutehill (east of the railway). Stone drifts are run south-south-west and south-south-east from the main shaft to these areas.

(1) *Tutehill area*.—The seam lies about 525 ft. below the surface, an average section being:—

Strong freestone roof ...	...	...	...	...	...	Ft.
Bannock Band Seam	{ Top Coal	...	...	...	...	2
	{ Fireclay	...	...	4 ft. to	...	6
	{ Bottom Coal	...	2 ft. 9 ins. to	...	...	3

The dip is south-west at 1 in 3 (15°), and the area is bounded on the north-west by a fault with a north-eastward down-throw of 194 ft.

(2) *Whillimoor area*.—The seam is badly faulted in this area, and is nowhere worked except west of the farmhouse, where it lies in a trough between a 72 ft. and a 60 ft. fault. The dip is eastward at a low angle.

The clay is pale and hard, and is said to comprise little or no 'ganister.' Reserves are small, since most of the clay is required for pack-walls in the mine. The long-wall method of working limits the amount of clay extracted. Thus very little clay is raised. It is sent in a raw state to the Cleator Moor and Carnforth Ironworks to be used for furnace-linings.

There is said to be a clay, suitable for making firebricks, beneath the Six-Quarters Coal; but none is raised.

BRANTHWAITE COLLIERY CO.

Branthwaite, *via* Cockermouth.

Branthwaite Mine & Mills.

Location: Mine situated about 150 yards N.W. of Branthwaite Station (Whitehaven, Cleator Moor & Egremont Railway).

Maps: One-inch New Ser. Ordnance 28, Old Ser. Geological 101 S.W.; six-inch Cumberland 62 N.W.

Latitude $54^\circ 36' 50''$. Longitude $3^\circ 27' 30''$.

Geological formation: Middle Coal Measures.

The beds worked here crop out from beneath Glacial deposits near the west bank of the River Marron, and the mine is approached by a drift or day-eye, running in a west-north-west direction for a distance of from 200 to 250 yards, and terminating about 50 ft. north of an old bore-hole. For two-thirds of this distance the beds dip gently north-west, and for the remaining one-third rise gently in the same direction. At its deepest the drift is 70 ft. from the surface of the ground.

An average section of the seam is as follows:—

'Ganister' [sandstone], lower part only, about	...	...	...	...	Ft. In.
Coal (position doubtful)	...	...	...	...	7 0
FIRECLAY, good quality	...	...	...	...	1 9
„ seconds, hard and ganister-like	...	...	...	...	3 0
					?

A large north-west and south-east fault throws the Coal Measures against Millstone Grit, a short distance east of the mine;

whilst in the mine itself three smaller faults, with the same direction, have been proved. From east to west, they are (1) 10 ft. down north-east, (2) 30 ft. down S.W., and (3) 33 ft. down S.W.

The fireclay contains little nodules of ironstone here and there, but not in sufficient numbers to require sorting out. The 'ganister' is a whitish felspathic sandstone¹ of medium-fine grain, with white mica and coaly fragments.

Reserves: The mine covers about 10 acres, and reserves, proved by neighbouring borings, appear to be ample.

Mode of working: The mine is worked by pillar-and-stall. Faults discovered to date give little trouble, and water is got rid of by a pump driven by water-power developed at the mills.

Wet and dry ground ganister is the chief output, and is made from mixtures of the ganister and fireclay.

WHITEHAVEN BRICK & TILE CO., LTD.

Low Road, Whitehaven.

Howgill Mine and Quarry and Whitehaven Brick and Tile Works.

Location: Mine and Quarries situated north of Cemetery, near Brick Works (Old Fire Brick Works), about $\frac{1}{2}$ mile south of Whitehaven.

Maps: One-inch New Ser. Ordnance 28, Old Ser. Geological 101 S.W.; six-inch Cumberland 67 N.W.

Latitude $54^{\circ} 32' 5''$. Longitude $3^{\circ} 35' 5''$.

Geological formation: Middle Coal Measures.

Mining operations were formerly carried on here by two stone drifts, situated one above the other; but more recently the measures have been quarried.

In the mine the low-level drift runs about 900 ft. into the hill in a direction slightly south of west. The mouth of the high-level drift, which is 180 ft. in length, is situated 360 ft. west of the mouth of the low drift and 66 ft. higher. The floor of the eastern or lower quarry runs westward to the mouth of the low drift, whilst the floor of the western or higher quarry overlies the low drift and runs up to the mouth of the high drift.

The quarries are separated by a fault, down east, situated close to, but east of, the step between the two quarries. Another fault, with similar hade, crosses the upper quarry at the mouth of the high drift, whilst beneath the high drift there is a series of step-faults, which combine with the westward dip of the strata (10° - 15°) to repeat any particular seam time after time.

In the upper quarry and in the drifts the most important beds are two coal-seams, Nos. 1 and 2, and their fireclays; the approximate thicknesses being given in the following section:—

										Ft.	Ins.
Measures	...	...	...	...	...	...	...	...	...	50	0
Coal No. 2	...	...	...	...	...	...	...	...	...	1	8
FIRECLAY No. 2	...	...	...	...	...	...	...	...	...	4	6
Measures	...	...	...	...	...	...	...	...	...	18	0
Coal No. 1	...	...	...	...	...	...	...	...	...	1	2
FIRECLAY No. 1	...	...	...	...	...	...	...	...	...	3	9
Measures	...	...	...	...	...	...	...	...	...	18	0

¹ Special Reports, Mineral Resources, vol. vi, Ganister, etc. (*Mem. Geol. Surv.*), Ed. 2, 1900, p. 92.

These are overlain by measures with four or five thin coals, only one of which (a 2 ft. coal) seems to have been worked.

In the lower quarry there are two thin coals, obscurely related to, but probably below the coals Nos. 1 and 2. The true position of the latter, in the geological sequence, appears to be a short distance above the Bannock Coal.

The top 12 inches of the fireclay No. 2 is the best for firebricks. Other parts of the fireclay contain ironstone-nodules. Firebricks are made only at intervals.

Reserves: There is a good reserve of fireclay, and the workings are being extended northwards.

Both clays were once dug for making sanitary sewage-pipes; but at the present time the chief output is common brick, made from blue clays lying between the coals and fireclays in the upper quarry. A few years ago the output comprised furnace-blocks, sleeves, stoppers, nozzles, boiler seating-blocks, and other refractory goods.

WYTHEMOOR COLLIERY CO., LTD., FRIZINGTON.

Barfs Silica Stone Co., Ltd., Harrington.

Wythemoor Colliery and Barfs Silica Stone Works.

Location: Colliery situated just south of Wythemoor Sough Farm, about 3 miles east of Harrington. Works situated a little over $\frac{1}{2}$ mile south of High Harrington, on the south-west side of the Cleator and Workington Railway.

Maps: One-inch New Ser. Ordnance 28, Old Ser. Geological 101 S.W.; six-inch Cumberland 61 N.E.

Colliery: Latitude $54^{\circ} 36' 40''$. Longitude $3^{\circ} 30' 5''$.

Works: Latitude $54^{\circ} 36' 25''$. Longitude $3^{\circ} 32' 40''$.

Geological formation: (? Lower) Coal Measures.

As stated above (p. 5) there is some doubt as to the exact position, in the Coal Measure sequence, of the seams worked in this pit. Their true correlation depends upon the correct identification of the bottom seam in the following section:—

Section at upcast shaft, Hannah Pit.

	Thickness.	Depth from	
		Ft.	Surface.
		Ins.	Ft.
Measures and Glacial drift	—		
No. 1.—Top seam	1 10	...	80
Fireclay (not yet worked)	3 0		
Measures (with coal 1 ft. and fireclay 3 ft., proved elsewhere)	—		
No. 2.—Two-foot Coal (probably = 43 yards or Micklam seam)	2 0	...	126
FIRECLAY 3ft. to	4 0		
Measures	—		
No. 3.—Coal (probably = Four-Foot)	3 2	...	336
Fireclay (full of ironstone balls). 2ft. 6 ins. to	3 0		

Between the two shafts the ground is faulted and the seams appear to be farther apart towards the east.

The Hannah Pit is sunk on a large fault (shown on the geological map) with a downthrow east of 60 fathoms. At the top

of the shaft the beds dip sharply towards the fault, but in the mine the usual dip is E.N.E. at 6° to 10° . A fault with downthrow north of 19 ft. has been proved about a quarter of a mile south of the two shafts. Its course is approximately W. 20° N. and E. 20° S.

The only fireclay raised is that of No. 2 seam—a fairly pure and constant bed with no ironstone-balls or ganister. It is thought that the underclay of the Top seam may be more refractory. A ganister-like rock occurs a little above No. 3 seam.

Reserves: Ample, in directions away from the eastern boundary fault.

Mode of working and treatment: The fireclay seam is worked by pillar-and-stall, the blue metal roof being used for packing; in the other seams longwall working is usual. The clay is not weathered because it is quickly used.

A little fine shattered Millstone Grit is added to the clay used for bricks, and shale also, quarried on the spot, is added for various purposes. Ground ganister¹ is made from a mixture of shale, fireclay and Millstone Grit, which is also quarried near the works. Ground fireclay is prepared for cement.

¹ Special Reports, Mineral Resources, vol. vi, Ganister, etc. (*Mem. Geol. Surv.*). Ed. 2, 1920, p. 91.

CHAPTER III.

LANCASHIRE.

BLACKBURN AND BURNLEY DISTRICT.

In the Blackburn-Burnley district the fireclay most useful for refractory purposes is undoubtedly the underclay of the Lower Mountain Mine or Ganister Coal. Other fireclays, such as those beneath the Cannel, Upper Mountain Mine and Inch Mine Coals, are occasionally used for this purpose, whilst in one case a clay some distance above the Upper Mountain Mine is worked in the Rossendale Forest district.

These beds all occur in the Lower Coal Measures or Ganister Beds, lying between the Arley Mine at the base of the Middle Coal Measures and the First Grit or Rough Rock of the Millstone Grit Series. A clay beneath the First Grit is worked for refractory purposes near Portsmouth, south-east of Burnley.

The following generalised section¹ of the strata in the Accrington district shows the positions of the above-mentioned seams:—

Generalised Section of Lower Coal Measures near Accrington.

Description.	Type Localities.	Thickness.			Depth below Arley Mine.		
		Yds.	Ft.	In.	Yds.	Ft.	In.
Shale and rag	—	15	1	0	—		
Rock	Riddle Scout ...	16	1	0	—		
Shale and raggy metals	}	99	2	0	131	1	0
Rock, rag and shale ...							
Rock (Coppice)	—	12	1	0	—		
Accrington and Enfield Shales.	Whinney Hill and Huncoat Brickworks.	40	0	0	—		
Pasture Mine Coal (mixed with shale and fireclay).	—	1	0	0	184	2	0
FIRECLAY	—		2	0	—		
Flag and Slate Rock ...	Crutchmoor Quarry and Bedlam.	20	0	0	—		
Shale	Higher Antley Brick works and Tom Dale Clough.	30	0	0	—		
Cannel Coal			1	0	235	0	0
FIRECLAY	The two mines appear to run together in Higher Antley Brick Quarry.	1	1	0	—		
Iconhurst Rock		10	0	0	—		
40 Yards (Upper Mountain Mine) Coal		1	0		246	2	6
FIRECLAY			1	0	—		

¹ Communicated by Mr. J. Ranson, F.G.S., Accrington.

Description.	Type Localities.	Thickness.			Depth below Arley Mine.		
		Yds.	Ft.	In.	Yds.	Ft.	In.
Warmden Rock ...	Warmden Quarry, Top Willows Lane and Warmden Clough.	14	0	0	—		
<i>Inch Mine Coal</i> ...	Warmden Clough and Willows Lane (6 in.)			1	261	0	7
FIRECLAY	—			1 6	—		
Shale	—	18	0	0	—		
<i>Upper Foot or Bullion Mine Coal</i> ...	Great Ark, Warmden			8	279	2	9
FIRECLAY	—			1 6	—		
Rock	{ Priestly Clough, Cockerlumb Fell and Valley, etc. }	9	0	0	—		
Shale					—		
<i>Ganister (Lower Mountain Mine) Coal</i> ...	Cat Hole Pit ...			2 0	299	0	3
FIRECLAY AND GANISTER	—	1	1	6	—		
Shale	—	12	0	0	—		
<i>Lower Foot Coal</i> ...	Hole-in-Bank Pit, or Jenny Lind Pit, Baxenden.			10	312	2	7
FIRECLAY	—			1 6	—		
Shale	—	26	0	0	—		
<i>Bassey Mine Coal</i> ...	—			2 6	340	0	7
FIRECLAY	—			5	—		
Woodhead Hill Rock ...	Railway Pit, Baxenden and Rishton Pit.	8	0	0	—		
Shale, up to	—	20	0	0	—		
<i>Ten Inch Coal</i>	—			10	—		
FIRECLAY	—			1 6	369	0	4
First Grit or Rough Rock, with Feather Edge Coal and FIRECLAY.							

Correlation with the Yorkshire District.

Blackburn District.

Yorkshire District.

40 Yards or Upper Mountain Mine and Fireclay.	= Halifax Hard Bed Band (or 36 Yards Band) and Fireclay.
'Ganister Mine' (Lower Mountain Mine) and Fireclay and Ganister.	= Halifax Hard Bed, or 'Ganister Coal' and Ganister.
Lower Foot Mine and Fireclay	= Middle Band or 'Clay Coal Seam' and Fireclay.
Bassey Mine Coal and Fireclay	= Halifax Soft Bed or 'Coking Coal' and Fireclay.
Ten Inch Coal and Fireclay	= Pot Clay Coal, and Stannington or Loxley Pot-Clay.

The fireclay of the Cannel Coal is now worked at Higher Antley, south of Accrington, where it appears to vary in quality. The coal is abnormally thick at this point, and there is reason to suspect that the Cannel and Upper Mountain Mines have come together, as at Hoddlesden farther south-west.

The Upper Mountain, or 40 Yards Mine fireclay is usually raised for making pipes, sanitary, glazed or acid-resisting ware.

It is a milder clay than that of the Lower Mountain Mine, and is made into firebricks at Clough Foot, between Todmorden and Bacup. Formerly it was used for this purpose near Shawforth and Littleborough.

The Inch Mine fireclay is worked in the Littleborough district for sanitary pipes and glazed goods, as well as fire-resisting wares, but it is probable that the Lower Mountain Mine clay at this locality is superior for the latter purpose. The Inch Mine seam is absent at Huncoat.

The Upper Foot or Bullion Mine is separated from the Lower Mountain or Ganister Mine in the district about Blackburn and Darwen, but in the Burnley coalfield the two seams become united and form the Mountain Four-Foot. The union occurs¹ along an irregular north-west and south-east line, a little south of Burnley (passing under Tooter Hill to the north of Foul Clough Colliery on the eastern side of Trough Edge), and the complex seam stretches under the whole of the Burnley Coalfield, reaching the surface in the Padiham, Colne and Portsmouth Valley districts. At Rishton the Bullion Coal is absent, its place being taken by a thin pyritous band with *Aviculopecten* shells at the top and bullions with goniatites at the bottom. The fireclay seat, however, is present.

The Lower Mountain Mine has a wide range, being found along the whole fringe of Lower Coal Measures, which border the margin of the Middle Measures in the west, north and east of the coalfield. In these districts the coal is usually good, but it deteriorates in quality in a southerly direction. As it lies almost invariably near the surface, and is a good coking coal, it has been mined extensively, especially in the north of the coalfield. In these operations its underclay also has been exploited, but there remains a great reserve of the clay, much of which could be worked near the outcrop, if worth while. The recent introduction of longwall workings into many of the collieries has led to a great falling off in the amount of clay raised as a by-product.

If the clay is mined specially for brickmaking it commands a higher price than when it is raised with the coal.

What is purported to be the Ganister Mine fireclay was formerly worked at the Cherry Tree brickworks, south of Blackburn.

The fireclay is associated with a so-called 'ganister,' which in comparison with the Sheffield ganister would be considered to be a siliceous fireclay. It usually underlies the fireclay, but (like the Halifax Hard Bed Ganister) may take its place by lateral passage, or occasionally overlie it. The more siliceous parts of the ganister are hard and will not break down on weathering, but the more aluminous parts become plastic and are added to the true fireclay in brickmaking. It is considered rather a nuisance in the mines as a rule, and if possible a step-up is made on to it, so that it becomes the floor of the mine. Its silica-percentage rarely

¹ Capt. John Aitken, 'On the Union of the Ganister and Higher Foot Coal Mines at Bacup.' *Trans. Manch. Geol. Soc.*, vol. v (1864-66), p. 185. and H. Bolton, 'The Nomenclature of the Seams of the Lancashire Lower Coal Measures.' *Trans. Manch. Geol. Soc.*, vol. xxv, 1898, p. 428.

exceeds 85, which unfits it for making silica-brick. Some of it, however, might be useful for making ganister compound if mixed with a rock like the best Warmden stone.

An average thickness for the underclay is 4 ft. 6 in.; of which the true upper fireclay averages 3 ft. 3 in. It seems probable that the ganister is most common towards the eastern margin of the coalfield.

The fireclay (? Lunch House Clay) worked at Sharneyford, near Bacup, lies in the midst of flagstones overlying the Upper Mountain Mine of Rossendale Forest, and has no coal associated with it.¹

Little has been done with the Arley Mine fireclay, which is 4 ft. in thickness in the Cliviger district, or with the fireclays of the overlying seams.

Details of past workings of fireclays are recorded in the 'Geology of the Burnley Coalfield,'² the 'Geology of Rossendale,'³ etc.

The clays are usually mined by shafts or day-levels. As a rule they are preferred weathered, the longer the better (in one case from 10 to 15 years). The Lower Mountain Mine fireclay breaks down to a plastic clay in one or two months. Much of the so-called ganister also becomes plastic on exposure and is employed for mixing with the milder clay. The Sharneyford, Clough Head clay (p. 33) is said to give better results when unweathered.

Grog is added in the form of broken brick or pipe and of burnt or raw 'ganister' or sandstone.

The time of firing is about seven—eight days, and the temperature reached 1300° C. in the case of the Lower Mountain fireclay. Other clays are burnt at a slightly lower temperature. Cones are not always used for testing, reliance being placed upon sighting. One firm made their own cones.

The total shrinkage is about 1 in. in 1 foot linear in hand-made or wire-cut firebricks made of Lower Mountain Mine clay, whilst in the machine-made and pressed bricks the shrinkage was $\frac{3}{4}$ in. to 1 foot. Other clays give a greater shrinkage.

Beside furnace and destructor blocks, ordinary firebricks, tiles, etc., the following specialities are made:—Linings for oil-furnaces in bolt-works, perforated firebricks, nose-block for shells, chequer bricks, frogs for blast-furnace stoves, skew-backs for locomotives, sight-hole blocks and stoppers, mouth-blocks and door-jambs for coke ovens, coke-oven bricks (in one case only used for linings of ovens).

The fire-resisting goods are chiefly used locally. No gas-retorts or crucibles are made. In some cases the fire-bricks made are only suitable for domestic purposes.

In the following table are shown the fireclays worked for the

¹ 'Geology of Rossendale,' by Capt. J. Aitken, in 'History of the Forest of Rossendale.' London, 1868, pp. 272-3, 281.

² *Mem. Geol. Surv.*, 1875.

³ *Op. cit.*

manufacture of fire-resisting goods in 1916, within the limits of the one-inch New Ser. Ordnance Sheet 76.

Locality.	Millstone Grit Series.	Lower Coal Measures.				
	Fireclay in shales below the Rough Rock.	Lower Mountain Mine Fireclay	Inch Mine Fireclay.	Upper Mountain Mine Fireclay.	'Cannel' Mine Fireclay.	Fireclay between flagstones above Upper Mountain Mine.
Sharneyford, Bacup	—
Accrington	—	...
Dulesgate, Clough- foot, Todmorden	—
Littleborough	...	little.	—	...	...	...
Yate and Pickup Bank, near Hod- dlesden	...	—
Hoddlesden	...	—
Darwen	...	—
Rishton	...	—
Whinney Hill and Moorfields, near Clayton-le-Moors	...	—
Huncoat and Ac- crington	...	—
Towneley	...	—
Portsmouth

THE HARDY BRICK & TILE COMPANY.

Willows Lane, Accrington.

Higher Antley Quarry and Headings.

Quarry: Situated about 1 mile south of Accrington Station.

Maps: One-inch New Ser. Ordnance 76, Old Ser. Geological 89 N.E., six-inch Lancashire 71 N.E.

Latitude $53^{\circ} 44' 30''$. Longitude $2^{\circ} 22' 15''$.

Geological formation: Lower Coal Measures or Ganister Beds.

The working-face of the quarry is at the south end where the following approximate thicknesses were obtained:—

	Ft.
Thin drift	—
Black Shale, iron-stained near top	25
'Cannel' [Foot] Coal (and ? Upper Mountain Mine), with thin dirt-band and ironstone 'nobbles'	2 to 3
Fireclay, in floor of pit	4
	—
	32
	—

A small slip or fault crosses the quarry obliquely from north-west to south-east, but it has little effect upon the beds, which dip towards the south at about 5° , causing the fireclay to come to the surface near the works. A little farther north the Upper Mountain Mine crops out, but there is a probability that the two mines

have run together and are worked as one in this quarry. In the immediate neighbourhood the measures are relatively unfaulted.

The fireclay is dark-grey to black in tint, and contains numerous plant-remains. The highest part is coaly and is used as an ingredient in common bricks, which are thereby improved. On the north-east side of the above-mentioned slip the fireclay has been stripped of cover and weathered *in situ* for some years. In one part of the pit the bottom of the clay is full of ironstone, but it is free from this detriment where it is now being worked. Some parts are of a more siliceous nature than the average.

Reserves: Reserves *in situ* are sufficient for many years, and future extensions will be chiefly made towards the south and east. The outcrop extends south-westward in the direction of two openworks near the Pottery (F. Ratcliffe, late Jas. Holdings & Sons), situated about $\frac{3}{4}$ mile south-west of the Higher Antley quarry. The shales above the 'Cannel' Coal are worked at these two openworks, and, before the war, were mixed with Lower Mountain Mine fireclay raised at Town Bent Colliery, Oswaldtwistle, for the manufacture of coke-oven bricks.

Mode of working: The coal is won from shallow headings and levels driven into the face of the quarry, leaving small pillars. These, on being blown away, cause a fall of the overlying clays, which are used for making ordinary bricks. The fireclay is then removed from the floor of the pit. Water occasionally gives trouble in wet weather.

GEORGE CLARKE & SONS, NORDEN FIRECLAY WORKS.

Rishton, Blackburn.

P. W. Pickup, Ltd., Rishton Colliery.

Rishton Colliery & Norden Fireclay Works.

Works situate $\frac{3}{4}$ mile north of Rishton Station, on the Leeds and Liverpool Canal.

Colliery situated $\frac{1}{4}$ mile north-east of Rishton Station (Lancs. & Yorks. Rly.).

Maps: One-inch New Ser. Ordnance 76. Old Ser. Geological 89 N.E. Works: Six-inch Lancashire 63 N.W. Colliery: 63 S.W.

Colliery: Latitude $53^{\circ} 45' 55''$. Longitude $2^{\circ} 24' 45''$.

Geological formation: Lower Coal Measures or Ganister Beds.

At Rishton Colliery the Lower Mountain Mine Coal and part of the underlying fireclay are worked. The upcast shaft, after passing through 70 ft. 7 in. of Glacial drift, enters the Lower Coal Measures at the position of the Pasture Mine Seam and passes through the 'Cannel,' Upper Mountain Mine and Inch Mine Coals with their fireclays, striking the top of the Lower Mountain Mine at a depth of 409 ft. 3 in. from the original surface-level. At the shaft the section of the Lower Mountain Mine seam is as follows:—

							Ft.	Ins.
Coal (old workings)	...	...	...	...	...	...	2	0
Good fireclay	...	...	...	...	...	...	1	8
Gritty fireclay ('ganister')	...	...	...	...	...	...	5	10

The shaft also passes through the underlying Devil's Den, Lower Foot and Bassey Mine Coals and fireclays, terminating in the Woodhead Hill rock at a depth of 530 ft.

The measures dip gently north-westward from the shaft, at about 4° , for nearly a mile, and then rise upwards steeply to the surface at an angle of 40° – 45° . The axis of this fold trends in a north-eastward direction through Blackburn and the Burnley Coalfield, where the Middle Coal Measures occupy the centre of the trough. Near Rishton the coals at the bottom of the trough are shattered.

The eastern part of the mine is separated from the western by a 30-yard fault, down west, and another of similar throw, down south, limits the mine on the south. There are also a few smaller faults. A fault is suspected on the far west of the property, cutting it off from the small exhausted Whitebirk Colliery.

Variations in thickness, from 2 to 3 ft., occur in the best fireclay, which is a pale-grey clay with plant-remains and some darker shaly portions near the top. Here and there it contains iron concretions; some small, others as large as loaves. The latter occurred in numbers near a fault. The good fireclay passes laterally into a 'ganister-like' rock by imperceptible gradations, the change taking place in about 400 yards, but sometimes it is a mixture of true fireclay and poor ganister. The ganister¹ occurs chiefly in the north-west part of the mine and at the eastern end. Towards the south-west it grades into the fireclay now being mined. The lower gritty fireclay or 'ganister' is not raised.

Reserves: At the Norden works there is distinct shortage of clay, and it is used as fast as it can be carted from the colliery tip-heap, which could easily be added to if necessary from the large reserves in the pit. At the works there is a supply of clay (Upper Mountain Mine) used for sanitary ware and second-class firebricks, and acquired from Ralph Entwistle & Co's late Cranberry Works, Darwen, where the Upper and Lower Mountain Mine Coals were both worked.

A small quantity of clay from G. Hargreaves & Co., Huncoat, has also been used here.

Mode of working: Formerly the mine was worked by pillar-and-stall, but longwall workings are now the rule, the faces advancing south-south-westward. Electric air-drills are used, and electric pumps keep the water under. When ganister sets in strongly, and is not wanted, a step-up is made on to it, and it becomes the floor of the mine, whilst some of the shale overlying the coal is removed to make head-room.

Treatment: Rishton clay is weathered as long as can be permitted and ground in a perforated dry pan with a little grog and previously-burnt 'ganister,' the fine dust being screened off for dusting moulds and for cement. The remainder goes either to the firebrick-making machine or to the wet-pan.

¹ This ganister is described in Special Reports. Mineral Resources, vol. vi, Ganister, etc. (*Mem. Geol. Surv.*). Ed. 2, 1920, p. 89.

Clay formerly mined at Darwen is made into fireclay goods for steam-boilers and cottages. Its chief use, however, is for sanitary and acid-resisting wares, which form a large part of the firm's output.

THOMAS KNOWLES, LTD.

Spring Vale Fireclay Works, Darwen.

Spring Vale Colliery & Fireclay Works.

Works and Quarry: Taylor's Green Pit and Works, situated about $\frac{1}{2}$ mile E. of Spring Vale Station (Lancs. & Yorks. Rly.).

Maps: One-inch New Ser. Ordnance 76, Old. Ser. Geological 89 N.E.; six-inch Lancashire 71 S.W.

Latitude $53^{\circ} 41' 20''$. Longitude $2^{\circ} 26' 40''$.

Geological formation: Lower Coal Measures or Ganister Beds.

The Lower Mountain Mine fireclay and what is left of the coal is worked here. The Top (upcast) shaft is $84\frac{1}{2}$ yards in depth to the Lower Mountain Mine, but passes through a fault. The measures between the Upper Mountain or Yard Mine, and the Lower Mountain or Half-Yard Mine are 69 yds. 2 ft. 9 in. in thickness and include the useless Bin Mine Coal and fireclay.

The Lower Mountain Mine coal averages 15 in. in thickness and is nearly worked out, whilst the fireclay attains a maximum of 6 ft., and overlies about 4-5 ft. of blue clay.

There are several faults in the property, the chief being (a) a downthrow north-east of 14 yards, which breaks the surface between the Top and Bottom pits, and is traversed by the Top pit shaft; (b) a downthrow north-east of 13 yards, which breaks the surface west of the Bottom pit, but is traversed by the shaft. Their trend is N.N.W. and S.S.E. Several smaller faults occur farther west. The beds are nearly horizontal on an east-and-west line. In the fireclay variations are common. Its colour ranges between black, near the top, to pale grey, and it passes imperceptibly here and there into a poor ganister or clayey siliceous silt with plant-remains. At one point the fireclay is only 8 in. in thickness and rests on 30 in. of ganister overlying the blue clay. Ironstone-balls are occasionally met with.

Reserves: Reserves in the mine are ample, especially towards the north and south, and a large stock is kept at the surface.

Mode of working: The mine is worked by pillar-and-stall, the faults precluding the use of the longwall method. Where necessary, sloping drifts are run from one seam to another across the faulted ground. Some of the ganister and parts of the fireclay containing much ironstone are waste.

Treatment: The fireclay is weathered as long as possible in tips, and ironstone and ganister picked out. The best heat-resisting brick is made from the top of the fireclay, but is liable to crack. A brick made, however, of crushed selected ganister will not crack. The lower layers of fireclay stand less heat. The bulk of the output consists of sanitary appliances, glazed goods and building requisites.

SHAW'S GLAZED BRICK CO., LTD.

Whitebirk, Darwen.

Waterside Pit & Brickworks.

Works situated on N.E. side of goods-line, $\frac{1}{2}$ mile N.N.W. of Hoddlesden Church, near Darwen (formerly at Whitebirk, near Rishton Colliery, Blackburn; see p. 24).

Pit situated $\frac{3}{4}$ mile N.N.E. of Hoddlesden Church, on Yate and Pickup Bank.

Maps: One-inch New Ser. Ordnance 76, Old Ser. Geological 89 N.E.; six-inch Lancashire 71 S.W.

Latitude $53^{\circ} 42' 25''$. Longitude $2^{\circ} 25' 30''$.

Geological formation: Lower Coal Measures or Ganister Beds.

The Lower Mountain Mine Seam is worked from a drift or day-eye directed a little west of south, and the average dip of the beds, allowing for faults, is S. 30° E. at about 6° or 7° .

A section of the seam is approximately as follows:—

									Ft. Ins.
Black Shale (roof)	...	...	...	...	...	...	...	...	—
Lower Mountain Mine Coal	...	...	...	...	...	...	...	...	1 3
" " Fireclay	...	...	...	...	...	...	...	...	3 6
White rock (nearly \approx ganister) on dark shale (floor)...	...	...	...	...	...	...	...	...	—

The mine extends in a south-south-east direction for about 1,000 yards from the entrance of the day-eye and is bounded on the east by a large fault of 300-400 yards throw, bringing Millstone Grit against Coal Measures. The seam crops out on the west. On the south-west there is a downthrow of about 120 yards, and at the south-south-east end of the mine a series of small step-faults counteracts the effect of dip.

Here and there, more especially near faults, the fireclay becomes ganister-like, but is still aluminous.

Reserves: There is a fair reserve of clay suitable for firebricks in the mine, which is being extended down dip, and all pillars are intact. Clay is also kept in tips at the works.

Mode of working: The mine is worked by pillar-and-stall, compressed-air drills operated by electric power being employed. Electric pumps are keeping down the water during temporary cessation of operations. The ganister is often waste.

Besides the fireclay mined here, some is acquired from J. Place & Sons, Hoddlesden Colliery (p. 28). and in making goods other than firebrick the two are usually blended with several other clays.

Treatment: Clay for firebricks is weathered for a short time at the works. It is then ground under edge-runners, with broken brick for grog, and tempered in a pan, pugged and wire-cut. Other bricks are made by the semi-dry process, and moulded in steam-driven re-press machines.

After drying, the bricks are fired in oblong kilns at a temperature near 1300° C. (Cone 10), the test-cones being the firm's own make. The best firebrick is usually made from selected Lower Mountain Mine fireclay; only such 'ganister' is added as will

weather down to a plastic material. Normally the bricks are rather soft, and will stand heating and cooling, but are said to be unsuitable for coke-oven doors.

The chief output of manufactured goods consists of acid-resisting ware, electric fittings, terra-cotta and glazed bricks. Firebricks are only a minor product.

JOSEPH PLACE & SONS, LTD.

Darwen.

Hoddlesden and Eccleshill Collieries and Sanitary Tube and Fireclay Works.

Situation: Eccleshill Works, and old mine, situated about $\frac{1}{2}$ mile N. of Darwen Station (Lancs. & Yorks. Rly.). Holker House Mine and Hoddlesden Works, situated about $\frac{1}{4}$ mile N.E. of Hoddlesden.

Maps: One-inch New Ser. Ordnance 76, Old Ser. Geological 89 N.E.; Eccleshill: six-inch Lancashire 70 S.E.; Hoddlesden: 71 S.W.

Hoddlesden: Latitude: $53^{\circ} 41' 50''$. Longitude $2^{\circ} 25' 30''$.

Geological formation: Lower Coal Measures or Ganister Beds.

The Lower Mountain Mine coal and fireclay were mined at Eccleshill Colliery, but the coal has almost all been got; and since it does not pay to work the clay alone, the mine is now closed down. The seam consists of 2 ft. of coal, on 4 ft. 9 in. of fireclay, on 1 ft. of impure ganister rock, the latter occurring at a depth of 87 yds. 0 ft. $\frac{1}{2}$ in. from the head of the shaft, which passed through the Cannel Mine, Upper Mountain Mine, Inch Mine and Bin Mine seams. Some of the Upper Mountain Mine fireclay was raised for making stoneware pipes. The beds dip south at 1 in 18 (3°). Here and there the fireclay changes into a poor ganister, when it forms one bed with the underlying rock.

Clay is now got from the Holker House Pit at Hoddlesden, where the Upper and Lower Mountain Mine fireclays are worked; but only the lower clay is used for fire-resisting goods, which are made up at the Eccleshill works.

At the pit the dip is N.N.W. at 1 in 12 (5°), and the workings are limited to the east and west by faults with a N.N.W. trend. In the Hoddlesden district the Cannel coal has come so close to the Upper Mountain (or Yard) Mine, that the two are only separated by a dirt parting, and are usually classed together as Upper Mountain Mine. The Inch Mine is not found here.

Hoddlesden Lower Mountain Mine clay is a rather light-grey to brown fireclay with remains of plants, but is black near the top, and contains a few small ironstone-balls. (The Eccleshill clay contains more and larger ones.) It changes horizontally from a rather mild and plastic clay to a whitish impure 'ganister,' which is hard to crush and unsuitable for making silica-brick. The Upper Mountain Mine fireclay is milder and will vitrify more easily than the lower clay.

Reserves: Reserves in the mine are large; in fact there is no lack of clay in the district, but it usually does not pay to work unless coal can be got at the same time.

Mode of working: At Holker House Pit working is by both pillar-and-stall and longwall, the latter method being employed when only coal is mined. 'Ganister' is often left as the floor of the mine, or is thrown away.

Treatment: The fireclay is weathered for about three to four weeks, in which time it breaks down to a plastic clay. Any 'ganister' that is brought, and will not break down, is put through a stone-breaker and added to the fireclay, which is ground beneath edge runners with a proportion of grog consisting of old sanitary pipes or bricks. The clay is tempered in a horizontal mixer and is then pugged and wire-cut into bricks.

The chief business of the firm is in sanitary ware, acid-resisting goods, glazed goods, electric cable conduits, builders' requirements, etc., which are made up chiefly at the Hoddlesden Works. Fire-resisting goods are a secondary product, and made only at Eccleshill, where sanitary pipes also were made before the war. The output of firebricks, etc., was greatly increased during the war.

GEORGE HARGREAVES & Co.

The Collieries, Wood Nook, Accrington.

Huncoat Pit and Fireclay Works.

Situation: On the north side of Huncoat Station.

Maps: One-inch New Ser. Ordnance 76, Old Ser. Geological 89 N.E.; six-inch Lancashire 63 N.E.

Latitude 53° 46' 25". Longitude 2° 20' 40".

Geological formation: Lower Coal Measures or Ganister Beds.

Fireclay is brought to the surface at Huncoat Pit, but some is also mined in Scaitecliffe Pit, Accrington (six-inch Lanes. 63 S.E.), with which there is an underground connection.

Huncoat No 2 Shaft, starting in measures below the Arley Mine, passes through seams from the Pasture Mine downwards to the Lower Mountain Mine coal and fireclay, the top of the latter occurring at 277 yds. 2 ft. 10½ in. from the surface. The fireclay rests on 3 in. of coal, known as the Hard Fold coal. In the shafts the Lower Mountain Mine coal is 2 ft. 8 in. in thickness and the fireclay 6 ft. 9 in., but in the mine the latter averages from 2 to 3 ft., and occasionally reaches a maximum of 10 ft. It is often siliceous, and 'ganister' sometimes sets in in its lower layers.

South-west of Huncoat Station there is a 60 yards fault, down north-east, with a N.W. and S.E. trend. Between this and Scaitecliffe Colliery there are eight other important faults.

Huncoat Mine is situated in a local syncline. On the south the beds dip N.N.W. towards Lake Side Bridge at 6° to 7°, whilst on the north the beds rise N.N.E. at a similar rate of inclination, and then tip over northward beneath the Middle Coal Measures of the Burnley Basin.

The fireclay varies from pale-grey to dark-grey in tint, but is black at the top, and varies in silica-content from point to point. It is full of remains of *Stigmaria* and rootlets and sometimes contains ironstone-balls or nodules, which are prone to occur in clumps rendering the clay useless. The ganister may contain a fairly high proportion of silica; in one sample as much as 84·8 per cent. has been found.

Reserves: Reserves of clay are large: towards the south-east of Huncoat Mine there is a large area yet to be worked, and plenty could be got from the mine if wanted. At the surface there is a dump of about 50,000 tons weathering down ready for use. The best clay lies in the direction of Accrington, but is often replaced by ganister.

The Company has control of, or is interested in, other collieries with Lower Mountain Mine fireclay:—

1. The Calder Colliery, Altham, where the fireclay is mainly of the 'ganister' type, very tough to drill and expensive to work. None is raised.
2. The Wood Nook Pit, Accrington, where very little clay is raised.
3. The Broad Oak Pit, Accrington, where the clay is soft and plastic and contains little ganister, but is mostly left in the mine.
4. The Goodshaw Hill and Baxenden Mines, in which the fireclay is rather good, but much is left below ground. At Baxenden the coal is worked out.

There is no shortage of fireclay in the surrounding district; to get it cheaply is the problem.

Mode of working: Formerly the beds between Scaitecliffe and Huncoat were worked by pillar-and-stall, but the longwall method is now in vogue, and is being actively employed on the south-east side of Huncoat Mine. By the old method from 50 to 100 tons of clay a day were raised, but now the average is from 10 to 15 tons a day. It must be noted that this is essentially a coal-mining company, and the clay is a by-product, hence the greater part of both ganister and clay is left underground.

Treatment: At the works, which are small and of recent origin, the clay is ground and tempered in a solid-bottom pan under edge-runners, old bricks being added for grog.

The fireclay is made into goods chiefly for works consumption. A siliceous firebrick for beehive coke-ovens was once made at Baxenden Colliery from Broad Oak clay and Warmden Stone.

BROOKS & BROOKS COLLIERIES, LTD.

Burnley.

Towneley Drift & Deanwood Mine & Towneley Brickworks.

Situation: Towneley Drift: about $\frac{1}{2}$ mile S.E. of the Works at Towneley Colliery. Deanwood Mine: $\frac{1}{2}$ mile N.W. of Portsmouth Station (Lancs. & Yorks. Rly.).

Maps: One-inch New Ser. Ordnance 76, Old Ser. Geological 88 N.W.; six-inch Lancashire 64 N.E. and 72 N.E.

Towneley Drift: Latitude $53^{\circ} 46' 15''$. Longitude $2^{\circ} 13' 40''$.

Deanwood Mine: Latitude $53^{\circ} 44' 10''$. Longitude $2^{\circ} 9' 40''$.

Geological formation: Lower Coal Measures and Millstone Grit.

Only two seams of clay are worked by this firm at present—namely, the Lower Mountain Mine fireclay and a seam of clay occurring between the Rough Rock and the Haslingden Flags. Sometimes the Upper Mountain Mine fireclay is worked, but is not used for firebricks. No fireclay is raised at Towneley Colliery itself. The shafts, however, pass through the Cliviger Valley Fault, which comes to the surface 100 yards west-south-west of the pit-head and has a downthrow north-east of about 500 yards. On this side the Arley, Yard, King and Dandy (Upper Arley) Coals of the Middle Coal Measures are worked. On the other side are the Lower Coal Measures. To the north-east of the fault the Arley Mine lies at 267 yards depth, whilst south-west of the fault the Lower Mountain Mine is at 140 yards.

Farther south, a drift has been run south-westward from the old King Shaft on the north-east side of the fault, through the faulted belt between Towneley Colliery and Towneley Drift, to tap the Lower Mountain Mine clay and coal, which will be mined forthwith.

At Towneley Drift the clay is worked from a day-eye, which descends slightly in a south-westward direction and then rises into the seam. The mouth of the day-eye and the point where the seam is struck are at about the same level (579 ft. O.D.).

The dip in the new ground reached from the King Pit is north-west at about 6° , but in the Drift Mine, farther south, it swings round first westward and then west-south-westward at about 5° , in the form of a pitching anticline.

Section of seam in Towneley Drift.

	Ft.	In.
Black shale with bullions (roof)	...	...
Upper Foot-Coal with bullions and Lower Mountain Mine Coal	3	0
Ironstone	1 in. to	10
Lower Mountain Mine Fireclay	3 ft. to	3 6
Ganister-like rock (floor)	...	...
	7	4

Every here and there the fireclay changes to impure ganister, as at Rishton and neighbouring places, but on the whole there is probably more ganister than true fireclay in this area. The Upper Mountain Mine fireclay has been worked here, and there is a large stock kept at the works.

Deanwood Mine, situated south-west of the Cliviger Valley Fault and the railway, is approached at outcrop by three day-eyes, which run south-westward into the hill, following the dip of the seam, which is a bed of clay (or shale), a short distance beneath the First Grit or Rough Rock of the Millstone Grit Series. This clay is darker and milder than the Lower Mountain Mine fireclay and contains fewer bullions. It is rough towards the bottom, and only the top 5 or 6 ft. is removed from beneath the shaly roof.

Reserves: There is a good reserve of clay in Towneley Drift and a new supply has been tapped from the old King Mine. Deanwood Mine has been worked since 1877, and shows no sign of exhaustion. Stocks of clay are kept at the works.

Mode of Working: All workings are by pillar-and-stall.

Treatment: Both the Deanwood clay and the Towneley Drift clay are weathered from a few months to several years.

At the works the clay is ground and tempered in separate pans. Sometimes the Lower Mountain Mine fireclay is used alone for fire-resisting goods, but usually a little Deanwood clay is mixed with it. It is said that the latter would make the best brick, but is too expensive to use alone.

The clays are used for making sanitary and glazed ware, and secondarily for fire-resisting goods.

In normal times about one-third of the output consists of fire-resisting goods, but the proportion is higher at the present day.

THE ALTHAM COLLIERY CO., LTD.

Accrington, Lancashire.

Whinney Hill & Moorfields Pits.

and

Accrington Brick & Tile Works.

Situation: Whinney Hill Pit & Accrington Brick & Tile Works, situated $\frac{1}{2}$ mile S.E. of Clayton-le-Moors. Moorfields Pit, situated $\frac{3}{4}$ mile E. of Clayton-le-Moors.

Maps: One-inch New Ser. Ordnance 76, Old Ser. Geological 89 N.E.; six-inch Lancashire 63 S.E.

Whinney Hill Pit & Brick Works: Latitude $53^{\circ} 46' 0''$. Longitude $2^{\circ} 22' 20''$.

Geological formation: Lower Coal Measures or Ganister Beds.

Whinney Hill Pit is connected underground with Moorfields and Great Harwood Collieries, but no fireclay is raised from the latter.

At Whinney Hill the shaft passes through the top of the Upper Mountain Mine seam at 130 yards and the Lower Mountain Mine seam at 180 yards from the surface.

Section of the Upper Mountain Mine seam:—

									Ft. In.
Coal	...	...	...	...	...	...	...	...	1 0
White rock	...	...	...	...	...	...	...	...	4
Fireclay, over	...	...	...	...	...	...	...	...	2 6

Section of the Lower Mountain Mine seam:—

Dark blue metal [shale, good roof]	...	...	...	...	...	...	—
Coal, increasing west to 3 ft. 6 ins.	...	...	...	...	...	...	2 6
Fireclay or 'ganister'	...	...	...	...	...	...	7 6
Thin coal, not mined	...	...	...	...	...	...	—

The beds dip N.N.W. at 8° in the direction of Hyndburn Bridge, where they are horizontal for a few hundred yards, after which they rise quickly to a slope of 20° or more. Hyndburn Bridge lies on the axis of the syncline that forms the northern

flank of the Lancashire coalfield (*see* under Rishton Colliery, p. 24).

There are no serious faults to interrupt work. That shown upon the one-inch geological map, trending from N.W. to S.E. and forming the western boundary of the Arley Mine basin, has been proved.

The Lower Mountain Mine fireclay is of the usual type. It is all called 'ganister' in these mines, but the relation of the true fireclay to the 'ganister' must be similar to that at Rishton Colliery. It contains very little ironstone.

Some of the Upper Mountain Mine fireclay is raised, but is not used for making firebricks.

Reserves: These are ample. The mines are primarily coal-mines, the fireclay being only a by-product; hence large quantities are left underground.

Mode of working: With the exception of the main roads, where pillars are left, the mines are worked by the longwall method, and very little fireclay is obtained.

Treatment: The fireclay is subjected to the usual treatment.

Firebricks are made by the Accrington Brick & Tile Co. for the Colliery Co. The chief wares of this Company are red bricks, tiles, pipes and acid-resisting goods made from the Accrington and Enfield clays (worked at the surface) and a little of the Upper Mountain fireclay. The bricks are used in the construction of the Altham Colliery Co.'s coke-ovens. Fireclay is ground for cement.

THOMAS TEMPERLEY & SON, LTD.

Sharneyford, near Bacup.

Clough Head Clay Mine.

Situation: Works, actually in Yorkshire, north of the Bacup-Todmorden road, near Holdengate, about 2 miles N.E. of Bacup Station (Lancs. & Yorks. Rly.). Clough Head Pit is situated a little over $\frac{1}{2}$ mile S.S.E. of the Brick Works, to which the coal is brought by a tramway.

Maps: One-inch New Ser. Ordnance 76, Old Ser. Geological 88 N.W.; six-inch Lancashire 72 N.E. (Yorks 229 S.W.). Clough Head Mine, six-inch, Lancashire 73 N.W.

Latitude $53^{\circ} 42' 50''$. Longitude $2^{\circ} 9' 40''$.

Geological formation: Lower Coal Measures or Ganister Beds.

The mine is entered from a day-eye situated a few yards north of the works, and extends in a north-north-westward direction for about 400 yds. Upon the east side the seam of clay crops out on the western bank of a small brook descending from Carn Crags Moor and dips W. 30° S. at nearly 12° .

No coal is associated with the bed of clay, which occupies a position some distance above the Upper Mountain Mine seam.¹ It averages 5 ft. 6 in. in thickness, and has a blue-black shale roof and a floor of grey false-bedded flaggy sandstone.

The locality of the mine is separated from the area south of the

¹ Cf. Lunch House Clay in J. Aitkin *loc. cit.*, p. 22.

The clay is of the usual type, rather mild, with very little ganister and few ironstone bullions.

Reserves: There is distinct shortage of clay, and the output of goods is small. Saunderclough Mine, in the same seam, was formerly worked by the company; and the clay was also worked at outcrop behind the works, until the boundary of the property was reached.

Mode of working: The mine is worked by pillar-and-stall.

RALPH ASHWORTH & Co., LTD.

Starring, Littleborough, Manchester.

(Owned by W. Dransfield & Sons, Moorside, Oldham).

Starring Mine & Works.

Situation: $1\frac{1}{2}$ miles W. of Littleborough Church, and just north of Dearnley Workhouse.

Maps: One-inch New Ser. Ordnance 76, Old Ser. Geological 88 N.W.; six-inch Lancashire 81 S.W.

Latitude $53^{\circ} 38' 35''$. Longitude $2^{\circ} 7' 5''$.

Geological formation: Lower Coal Measures or Ganister Beds.

The only seam being worked at the time of our visit (1916) was the Inch-Mine Fireclay.

The shaft starts close to the outcrop of the 40 Yds. Mine (Upper Mountain Mine), and goes down to the Little Mountain Mine beneath the Lower Mountain Mine. The Mine is also approached by a day-eye. The shaft-section is as follows:—

	Thickness. Yds. Ft. In.		
40 Yds. Mine and fireclay (nearly worked out.)			
Bluish shale	15	0	0
Inch-Mine Coal			1
Inch Mine Fireclay (now worked)	2	1	6
Measures	37	1	6
Upper Foot Mine (temporarily abandoned)			
Measures			
Lower Mountain Mine Coal			
" " ganister		1	6
" " fireclay		2	6
(almost untouched)			
Measures			—
Little Mountain Mine Coal			—
(worked out).			

The dip is S.S.E. at 3° , and the contour of the ground is such that the seam crops out on the east, north and west of an isolated hill, lying between two N.N.W.-S.S.E. faults, shown on the one-inch Geological Map. The mine itself is fairly free from faults, and has been worked in a direction between north-west and west-north-west.

In an openwork at outcrop, close to the works, the Inch-Mine Coal, measuring from 1 to 4 ins. in thickness, can be seen overlying 9 ft. of fireclay. The coal is covered by 9 or 10 ft. of blue-black shales.

The Inch-Mine fireclay is bluish-grey, weathering slightly yellow, and contains plant-remains. It is fairly uniform, with the exception of bullions, about the size of the fist, at the bottom and in a thin bed halfway up. Of the other underclays occurring here, that of the Lower Mountain Mine usually consists of ganister overlying fireclay, whilst occasionally the whole seam may be either ganister or fireclay. Only a little has been raised.

Reserves: Reserves of the Inch-Mine Clay are ample. The mine extends 520 yds. in a north-west direction from the shaft, and is nearly half this width. Only a few of the pillars have been worked out and several acres of ground are untouched. In normal times 250 tons a week are raised. The Lower Mountain Mine fireclay forms a valuable reserve.

Mode of working: The whole mine is worked by pillar-and-stall. In the clay-mine naked lights can be used; the roads are high and dry and little timber is required. Faults give no trouble, but bullions cause a little waste. Owing to scarcity of labour some clay is now worked at outcrop and mixed with the mined clay.

Treatment: The clay is weathered as long as possible to rid it of deleterious salts and to expose the bullions; it is then prepared for the wirecutters or moulding tables in the usual manner. Old pipes and bricks are used for grog, and occasionally a little crushed sandstone, obtained from a small excavation at the works, is added. This is a felspathic rock situated a little above the Upper Mountain Mine seam. It is also used for dusting bricks and moulds.

The total linear shrinkage is $1\frac{1}{2}$ in. in 1 ft. for Inch-Mine clay, and 1 in. in 1 ft. in the case of Lower Mountain Mine clay.

Before the war the chief manufactured goods made of Inch-Mine clay consisted of sanitary pipes and glazed ware, but more fire-resisting goods are now made. Ground and lump fireclay are also sold. The Lower Mountain Mine fireclay would probably make a better brick, but has not yet been exploited.

CHAPTER IV.

LANCASHIRE.

WIGAN—HORWICH AND ST. HELENS DISTRICT.

The fireclays of South Lancashire occur in the Lower, the Middle and the Upper Coal Measures, but mainly in the Lower Measures or Ganister Beds.

These lower measures form wide outcrops in the neighbourhood of Horwich and around Upholland, near Wigan; their principal coal-seams being the Upper, Middle and Lower Mountain Mines.¹ With each of these seams fireclays are associated, but the best fireclay underlies the Middle Mountain Mine. At Horwich, what is said to be one of the Mountain Mine seams of clay attains a thickness of 2 ft., and at Upholland of 12 ft., while farther south, at Bispham Hall, the Middle Mountain Mine fireclay has a thickness of 13 ft. The total thickness of the Lower Coal or Ganister Measures near Wigan is about 1,800 ft.²

In the Middle Coal Measures there are many seams of workable fireclay, but they are not everywhere suitable for refractory wares. Thus those worked near St. Helens are not worked at Wigan, and *vice versa*. The names of the principal seams of coal and the positions of the fireclays and also their depths from the surface are indicated in the following sections³:—

Section at Garswood Hall Colliery, Wigan.

	Depth in Ft.
New Mine	100
Ince Yard	125
(Fireclay)	
Four-Foot Ince	200
Seven-Foot Ince	285
Thin-Coals = Yard Mine	—
Two-Foot Pemberton	650
Five-Foot Pemberton	700
(Fireclay)	
Five-Foot Wigan	1030
Four-Foot Wigan	1140
(Fireclay)	
Nine-Foot Wigan or Trencherbone	1200
(Fireclay)	
Ravin Mine Hoo Cannel	1550
Yard Mine	1630
Five-Foot Orrel	1960
Arley Mine	2150

¹ In Lancashire, coal-seams are known indifferently as 'mines,' 'delfs,' and 'coals.'

² 'The Geology of the Country around Wigan' (*Mem. Geol. Surv.*) 1862, p. 9.

³ Abridged from Horizontal Sections, Sheet 61. (*Geol. Surv.*)

The section of the Deep pit, St. Helens Colliery, given below, may be taken as representative of the sequence of the Middle Coal Measures in the neighbourhood of St. Helens¹. The names of the principal coals and the positions of the fireclays worked at the several localities described on pp. 43 and 44 are shown in the following section:—

Section at Deep Pit, St. Helens Colliery.

	Depth in Ft.
Lyons Delf	170
London Delf	225
Potato Delf	300
Earthy Delf	350
(Fireclay)	
Coals. Little Delf	—
St. Helens Main Delf	640
Cannel Coal	660
Four-Foot Mine	685
Higher Pigeon-House Coal	740
Fireclay (Park Mine)	
Lower Pigeon-House Coal	755
Ravenhead Main Delf	1030
Bastion Delf	1090
Roger Coal	1120
Flaggy Delf	1350
Roger Main Coal	1425
Rushy Park Coal	1780
Arley Mine	1970

In the Upper Coal Measures fireclays are worked by the Sutton Heath and Lea Green Collieries at Roughdales, where they are faulted against red and purple marls (? Permian), which also are dug for the manufacture of special kinds of refractory goods. A seam of true fireclay lies about 290 yards above the Potato Delf.

Manufacture: In South Lancashire refractory fireclay goods do not form an important part of the clay output. Except at Messrs. Adam Mason & Sons' works at Horwich, where stoppers, sleeves and tuyeres (also magnesite and chromite bricks) are made, the production of refractory ware is limited to the more common fire-bricks, blocks, etc. A small amount of ground clay is sold.

On the other hand, glazed sanitary ware is the staple product of Messrs. The John Crankshaw Co. and W. & R. Pickup at Horwich. 'Metallic' bricks, blue and brindled bricks and tiles form the chief product of the Ravenhead Sanitary Pipe & Brick Co., Upholland. The Sutton Heath & Lea Green Collieries Co., make acid-resisting blue and brindled bricks. These and the other firms mentioned in the following pages make a certain amount of ordinary refractory brick.

¹ Geology of Wigan (*Mem. Geol. Surv.*), 1862, p. 12.

THE JOHN CRANKSHAW CO., LTD.

with which is amalgamated

W. & R. PICKUP & CO., LTD., HORWICH.

Works: The Brickworks (Crankshaw's) at Wildersmoor. The Pipeworks (Pickup's) at Horwich, near the Station.

Mine: The day-eye at Horwich is about half a mile north of Horwich Station and east of Lower Rivington reservoir.

Maps: One-inch New Ser. 84, Old Ser. Geological 89 S.E.; six-inch Lancashire 86 N.W.

Mine: Latitude $53^{\circ} 36' 30''$. Longitude $2^{\circ} 32' 30''$.

Geological formation: Lower Coal Measures.

The seam of fireclay worked, which is about 18 in. to 3 ft. thick, and is overlain by a Coal 11 in. thick, said to be one of the Mountain Mines. The beds dip a little east of north at about 1 in 9. A large fault on the southern side of the property with downthrow to the south (amount not proven) runs east and west. Another fault trends north-north-west and south-south-east, with a downthrow east of 9 ft.; the same fault farther north throws the beds down 6 ft. to the east, but at the end of the main brow the throw is only $1\frac{1}{2}$ ft. All the beds are worked by a day-level about 1,000 yards long with side galleries. The fireclay is grey in colour, and is generally of one quality throughout.

Reserves: The reserves of fireclay are considered to be ample for all immediate and prospective requirements even if the work is extended.

Method of working: Both coal and clay are worked on the pillar-and-stall system. There is no trouble with water as it all drains away through the adit.

Treatment: There are large dumps weathering for six months; the dumps are not allowed to be drawn on below the minimum of 18,000 tons. Weathering exposes the ironstone nodules, which are then removed by hand-picking. The grog added consists of burnt clay and damaged pipes.

ADAM MASON & SONS, LTD.

Horwich, near Bolton.

Montcliffe Mine.

Works: In Chorley New Road, adjoining Horwich Station (Lancs. & Yorks. Rly.).

Mine: Montcliffe Mine: one mile E.N.E. of Horwich Station.

Maps: One-inch New Ser. Ordnance 84; Old Ser. Geological 89 S.E.; six-inch Lancashire 86.

Latitude $53^{\circ} 36' 20''$. Longitude $2^{\circ} 31' 20''$.

Geological formation: Millstone Grit (?) According to the Geological Survey Map the fireclay is in the Millstone Grit, but the local mining engineers consider it to be in the Lower Coal Measures and call it the Mountain Mine Fireclay.

Section at No. 2 (Winding) Shaft.¹

								Thickness.
								Ft. In.
Rock	...	...	...	...	...	...	...	90 0
Margery Coal	...	...	...	...	...	...	...	3 0
Soft Rock	...	...	...	...	...	...	...	90 0
Soft metal	...	...	...	...	...	...	...	90 0
Rock	...	...	...	...	...	...	...	85 0
Top Coal, inferior, 1 ft. 0 in. not worked	Mountain Mine.							5 10
Dirt and Coal Bands, 1 ft. 8 in. not worked								
Fireclay, 1 ft. 8 in. worked								
Bottom Coal, 1 ft. 6 in. worked								
Soft dirt, 3 in.								8
Fireclay, 5 in. good, but not working								66 0
Rock bands, hard rock and metal	...	...	...	...	...	...	...
Total depth to adit	...	...	...	...	...	...	...	430 6

The beds dip south at 8°. In the workings there are three faults running approximately parallel to one another. One hades north-west, but its downthrow is unknown; the second also hades north-west, with a downthrow of 23 yards; the third hades north with a downthrow of 30 yards.

Reserves: There are plenty of reserves both along strike and down dip.

Mode of working: The coal and clay are worked on the longwall system. Water gives no trouble.

Treatment: Weathering of the clay takes twelve months. Coal used in the kilns is dug at the pit. The grog used consists of burnt clay, supplemented in some cases by a siliceous stone ground for the purpose.

THE RAVENHEAD SANITARY PIPE & BRICK CO., LTD.

UPHOLLAND BRICK & TILE WORKS.

Upholland, near Wigan.

Situation: The open pits and works are situated about two-thirds of a mile west of Upholland Church.

Maps: One-inch New Ser. Ordnance 84, Old Ser. Geological 89 S.W.; six-inch Lancashire 93.

Latitude 53° 32' 20". Longitude 2° 44' 10".

Geological formation: Lower Coal Measures or Ganister Beds.

Section at northern end of pit:—

				Ft.
Middle Mountain Mine.	{	Common brick shale	...	10
		Coal	...	18 to 21 ins.
		FIRECLAY, light-coloured at top of seam	...	
		and nearly black at base (working)	...	10 to 12
		Coal, Riding Mine	...	1½
		Ganister No. 2.	...	1 to 5

¹ Information by Mr. W. Tong, Mining Engineer to the Company.

Section at eastern face of pit, here about 100 ft. high and 600 ft. long.

		Ft.
Common brick shale, with some stone bands (ganister)		70
Middle	{ Coal	1½ to 2
Mountain	{ FIRECLAY (working)	12
Mine.	{ Riding Mine Coal	1½

Section at western end of pit:—

	Ft.
Riding Mine Coal	1½
Ganister No. 2	1 to 5
Shale	50
GANISTER No. 1 (working)	10
Shale, proved to	10

The beds dip E. at 1 in 6.

There is a disused quarry about 150 to 200 yards east of the above pit where ganister No. 3 occurs. The rock was formerly quarried and ground to mix with the fireclay.

Reserves: There are ample reserves of fireclay and ganister stone, along the strike to the north and south and along the dip.

Water level is below the bottom of the quarry. Considerable labour is involved in removing 'boulders' or large nodules of clay ironstone.

The Ravenhead Co. have another large quarry at Ravenhead, St. Helens, in the Middle Coal Measures, where there are seams 6 to 8 ft. thick of silica rock which might be suitable for the manufacture of silica bricks.

At Ravenhead quarry are at least six seams of bastard fireclay which on being mixed with suitable proportions of ground silica rock would make a good firebrick, and it is not unlikely that such bricks will be made at Ravenhead. At present no refractory goods except boiler and kiln pieces are made at these works, all the fire-bricks, etc., being manufactured at Upholland.

Mode of working: The clay and shale is either blasted or got by hand; it is not weathered at all. The fireclay from the three parts of the pit is not separated but all mixed together. There are many 'kernels' of ferruginous clay which are picked out by hand.

WIGAN COAL & IRON CO., LTD.

Wigan.

Situation: The Taylor Pit, near Standish; Hewlett Pit, east of Hindley Station; Lindsay Pit, near Haigh; and Eatock Pit, near Westhoughton.

Maps: One-inch New Ser. Ordnance 84; Old Ser. Geological 89 S.W. six-inch Lancashire 93.

Geological formation: Middle Coal Measures.

The following are rough sections of the seams from which common fireclay is got:—

No. 1 Yard Seam—								Ft. In.
Coal	...	...	...	...	...	...	...	1 9
Dirt	...	...	...	...	...	...	...	1 9
Coal	...	...	...	...	...	...	...	1 8
Black dirt	...	...	...	...	...	...	...	1 9
FIRECLAY	...	...	...	...	...	...	...	3 0

Wigan 4 Ft. Seam—								Ft. In.
Dark blue metal	...	...	...	...	...	...	...	1 4
Coal	...	...	...	...	...	...	...	2 3
Pricking Coal	...	...	...	...	...	...	...	5
Warrant	...	...	...	...	...	...	...	6
FIRECLAY	...	...	...	...	...	...	...	1 0

Trencherbone Seam—								Ft. In.
Clod	...	...	...	...	...	...	...	1 0
Coal	...	...	...	...	...	...	...	2 9
FIRECLAY	...	...	...	...	...	...	...	1 0

Eatocks Yard Seam—								Ft. In.
Coal	...	...	...	...	...	...	...	1 3
Dirt	...	...	...	...	...	...	...	1 3
Coal	...	...	...	...	...	...	...	2 0
Warrant	...	...	...	...	...	...	...	3
FIRECLAY	...	...	...	...	...	...	...	2 6

Lindsay Pit—

The Pemberton Five-Foot Mine—

Bat	...	...	...	...	...	...	...	1
Coal	...	...	...	...	...	...	...	5 2½
FIRECLAY	...	...	...	...	...	...	...	6

The Company make boiler-flue pieces from clay from their own mines, but this clay is not good enough for blast-furnace work, although it is quite suitable for boiler-flues and daub for tapping-holes.

Reserves: There are plentiful reserves of these fireclays in the various pits of the Company.

Mode of working: All the mines are worked on the pillar-and-stall system.

Treatment: All the clay is weathered.

BISPHAM HALL COLLIERY CO.

Orrell, near Wigan.

Situation: Brickworks Department, half a mile west of Great Moss Pit. Mine, Bispham Hall Gauntley Pit, and openworks adjoining brickworks.

Maps: One-inch New Ser. 84; Old Ser. Geological 89 S.W.; six-inch Lancashire 93.

(Gauntley Pit). Latitude 53° 31' 20". Longitude 2° 43' 20".

Geological formation: Lower Coal Measures.

There are two seams of fireclay working, one below the Middle Mountain Mine in the Gauntley Pit, the second underlies the Upper Mountain Mine in the openworks.

In the pit the seam of fireclay is 52 yards from the surface, 5 to 13 ft. thick, and it lies below the Middle Mountain Mine Coal.

The Lower Mountain Mine underclay also occurs in the pit, but is not refractory and is used for other classes of goods.

The section at the openworks is as follows:—

Upper Mountain Mine Coal	...	...	...	...	Ft.
" Fireclay (working)	...	...	...	...	5 to 6
Shale, used for non-refractory wares	...	...	...	...	6

The dip of the beds is E. at 1 in 4. There is very little faulting in the mine. The bulk of the fireclay used is from the pit, not the openworks.

Reserves: Ample for many years, including good reserves on tips. The seams are limited by the Tinkerhole fault, half a mile W.N.W. of the collieries.

Mode of working: Water is troublesome, but can be disposed of by the existing machinery. No waste with clay except some cannocks.

Gauntley Pit is worked for the most part on the long-wall system, but about a quarter of it on pillar-and-stall system.

The clay varies in quality: that lying immediately below the coal being black in colour and richer in silica than the rest. The best clay is carefully selected but not all is taken out, some being left to enrich the remainder of inferior quality; about a third, however, is taken.

Treatment: All the clay is weathered for a period of three years. It is blended, mixed with Granham's Moor stone and Ruabon stone, and is mixed in different proportions for different purposes. The grog added is the firm's own clay specially burnt, and some sand.

THE GREENGATE BRICK & TILE CO.

with which is amalgamated

WOOD & CO.

(JNO. J. BATE, PROPRIETOR)

Ravenhead, St. Helens, Lancs.

Situation: Park Mine (Bate) openworks about $\frac{3}{4}$ mile S. of St. Helens; Wood's openworks about $\frac{1}{4}$ mile S. of St. Helens.

Maps: One-inch New Ser. 84, Old Ser. Geological 80 N.W.; six-inch Lancashire 107.

(Wood's Pit) Latitude $53^{\circ} 26' 40''$. Longitude $2^{\circ} 44' 15''$.

(Bate's Pit) Latitude $53^{\circ} 26' 20''$. Longitude $2^{\circ} 44' 45''$.

Geological formation: Middle Coal Measures.

Bate's Openworks and 'Brow' or Slant.

The brow is worked down the dip and is about 60 ft. long at present.

The coal is the seam below the Lower Pigeonhouse Mine and attains a thickness of 1 ft. 7 in. It is underlain by fireclay (Park Mine) 4 ft. thick. The beds dip E. at 1 in 3.

Wood and Co. Openworks and Brows:—

				Ft. In.	Ft. In.
Earthy Delf	{	Coal	1	8	
		Clay		4	
		Coal	1	8	
		Clay		4	
		Coal	2	8	
Measures					6 8
Yard Coal [worked]					20 0
Fireclay (Yard) [not worked]					1 to 3
Measures					4 0
					60 0
New Mine Coal (? St. Helens Main Coal)					4 8

The Yard Mine fireclay could easily be developed by brow. The dip is E. at 1 in 6.

Reserves: There are plenty of reserves of both coal and fireclay at both localities, down dip and along strike as the beds are practically unfaulted.

Method of working: The method of working is pillar-and-stall.

The Park Mine fireclay is weathered for a few weeks. Grog consists of broken-up saggars, made of Glenboig fireclay, supplied by adjacent jam-pot factory. Also rock from the quarry (ganister) is ground and added.

SUTTON HEATH & LEA GREEN COLLIERIES CO., LTD.

St. Helens.

Works: Roughdales Brickwork Department, situated about $1\frac{1}{4}$ miles west-south-west of St. Helens Junction.

Pit: An openworking adjoins the brickworks.

Maps: One-inch New Ser. 97, Old Ser. Geological 80 N.W.; six-inch Lancashire 108.

Latitude $53^{\circ} 25' 43''$. Longitude $2^{\circ} 44' 34''$.

Geological formation: Upper Coal Measures.

The bed of fireclay is worked in a large open pit at Roughdales. It is about 8 ft. thick and lies 290 yards above the Potato Delf and is, therefore, probably of Upper Coal Measure Age.¹ The beds dip east at 1 in 6 and are much faulted.

Red marls also are dug at the southern end of the same open pit for making brindled bricks. These marls are separated from the fireclay by a fault which is said to have a downthrow south of some 80 yards. The beds are described locally as Permian, but on the Survey map are classed as Coal Measures and so described in the Memoir above mentioned.

Reserves: The clay and marls cover an area estimated at 30 acres. There is another seam of fireclay in the Coal Measures at the Sutton Heath Pit belonging to the same Company, but it is not now being worked.

Treatment: The fireclay and marl are not weathered but sent straight to the brickworks. No grog is added. The fireclay is used in making firebricks. Brindled bricks for acid-resisting purposes are made from the red and purple marls.

¹ 'The Geology of Prescott' (*Mem. Geol. Surv.*), 1882, p. 10.

CHAPTER V.

EAST CHESHIRE & SOUTH-EAST LANCASHIRE.

INTRODUCTION.

The fireclays used in this district for refractory purposes are obtained mainly from the Lower Coal Measures, though a few are referable to the Middle Coal Measures and Millstone Grit. They usually occur as underclays of coal-seams, which in this district are known as 'mines.' They are as follows, in descending order:—

Middle Coal Measures:—

Two fireclays at or close below the horizon of the Worsley Four-Foot Coal, at Croal Brickworks, Farnworth, near Bolton.

Lower Coal Measures:—

White-Ash or Half-Yard Fireclay (? the Upper Foot or Bullion Mine Fireclay), at Furness Vale, Goyt Valley, near Stockport.

Ganister or Lower Mountain Mine Fireclay, at Bollington and Pott Shrigley near Macclesfield, at Besom Hill near Oldham, and at Doffcocker near Bolton.

Lower Foot Mine Fireclay, at Bollington, at Thurston Clough, Delph, near Oldham, and at Jericho, near Bury.

A fireclay (known as the No. 2 Clay) that occurs 18 ft. below the Lower Foot Mine at Thurston Clough.

Millstone Grit:—

A fireclay called the Victoria Fireclay, immediately overlying the First or Upper Bed of the Third Grit at Grotton, near Oldham.

The Victoria Fireclay is known only at Grotton, but as it has not yet been opened up, little can be said of its character.

The No. 2 Clay at Thurston Clough, Delph, is the underclay of a 5-inch coal (the No. 2 Coal). Its position with respect to the Lower Foot Mine Coal is shown in the Section on p. 54. The clay, which is 4 ft. 6 in. thick, has a black top.

The Lower Foot Mine Coal, known in the Macclesfield district as the Stinkard or Stone Mine, varies in thickness from 10 in. to 1 ft., and its underlying fireclay varies from 4 ft. to 6 ft. At Jericho, near Bury, the uppermost 6 in. are darker in colour than the rest. The Lower Foot Mine Clay is regarded as of lower quality than the Ganister Mine Clay, and where the two clays are worked in the same mine the Lower Foot Mine Clay is used for low refractory goods and sanitary ware.

The underclay of the Ganister or Lower Mountain Mine is the one most frequently used in this district. The coal, which appears to be represented in the Macclesfield district¹ by the Sweet Seam, varies in thickness from 1 ft. 6 in. to 2 ft. 2 in. The underclay consists partly of fireclay, partly of ganister. In some places, as at Bollington, the ganister, in the form of impersistent masses 4 in. to 1 ft. thick, overlies the fireclay. Elsewhere, as at Doffcocker, near Bolton, the coal occurs as two bands divided by fireclay, with the ganister band 1 ft. 6 in. to 2 ft. thick between the fireclay and the lower coal-band; the fireclay and ganister together range in thickness from 3 ft. 6 in. up to 7 ft.

The fireclay varies in character in a vertical direction, at one mine the upper two-sevenths being apparently less siliceous than the lower five-sevenths, to which the name 'silica-rock' is given by the firm. At an adjacent mine the upper half of the fireclay is classed as 'best clay,' while the lower half is called 'seconds clay.'

The ganister is a hard siliceous fireclay, light grey in colour, and permeated by stigmarian rootlets; its silica-percentage is said to be 88 and its alumina-percentage 7 to 8. It is little affected by weathering, and as it is difficult to grind, it appears to be little valued, except as a means of raising the silica-percentage of clay mixtures intended for high-temperature goods, and as a source of ground ganister.

Neither the so-called silica-rock nor the ganister would of itself serve for the production of silica-bricks, but the ganister may prove to be a useful ingredient in the manufacture of siliceous firebricks.

The Upper Foot or Bullion Mine appears to be the Little Smut or Lower Smut of the Macclesfield district, where it is said to occur 36 ft. above the Sweet or Ganister Mine. It is represented in the Bakestone Dale Moorside Shaft at Pott Shrigley (p. 48) probably by an 8-in. coal 51 ft. above the Sweet Coal, and at Furness Vale by the White-Ash or Half-Yard Coal, which lies 30 ft. above the Ganister Mine. At Besom Hill, near Oldham, the distance between the Ganister Mine and the Upper Foot Mine is said to be 45 ft. The coal varies from 8 in. to 13 in. in thickness.

The underlying fireclay is 3 ft. thick at Furness Vale, where the upper 2 ft. are classed as 'best quality' and the lower foot as 'seconds.' Trade analyses show that the top part of the seam contains 55 per cent. of silica, and the lower part 63 per cent.

The two fireclays at or close under the Worsley Four-Foot Coal at Croal Brickworks, Farnworth, are at present worked but slightly. The lower bed is 2 ft. to 3 ft. thick; the upper bed is 1 ft. to 1 ft. 6 in. thick, and is overlain by a thin coal-seam. The exact position of the two clays with respect to the Worsley Four-Foot Coal appears to be unknown.

Manufacture: The fireclays are usually weathered as long as possible and ground under edge-runners, commonly in a perforated 'dry' pan, except for some of the larger goods—e.g.,

¹ The Geology of the Country round Stockport, Macclesfield, Congleton and Leek,' by E. Hull and A. H. Green (*Mem. Geol. Surv.*), 1866, p. 23.

furnace blocks, in which case solid bottomed 'wet' pans are used. About 5 per cent. of old firebrick grog is introduced. For firebricks hand-moulding is the normal method, followed by branding in a hand press. Recently there has been an extension of the number of wire-cut bricks owing to the dearth of labour. A minority of firms employ the semi-dry machine process.

Firing is conducted in round or oblong down-draught kilns (the former are the more numerous) or in continuous kilns of the Hoffmann or Newcastle types.

Ordinary firebricks, furnace and cupola blocks, boiler seatings, firebacks and cheeks and ground fireclay form the bulk of the refractory ware produced in the district. Gas retorts are made at Pott Shrigley. Coke-oven bricks, sleeves, stoppers and nozzles are made at Furness Vale. Glazed sanitary ware is manufactured at Dukinfield, Doffcocker and Grotton. There seems to be a tendency in the direction of raising the output of siliceous and ganister bricks, which at present is small.

East Cheshire.

JOHN HALL & SON (DUKINFIELD), LTD.

Dukinfield, Manchester.

Works: Brickworks at Dukinfield. Established 1792.

Mine: Clays obtained from the Clarence Fireclay Mine, Adlington. The mine, which is worked by shaft and level, is situated about one furlong east of Sugar Lane Farm, half a mile N.W. of Bollington, 3 miles N.N.E. of Macclesfield.

Maps: One-inch New Ser. Ordnance 98, Old Ser. Geological 81 N.W.; six-inch Cheshire 29 S.W.

Latitude 53° 18' 12". Longitude 2° 5' 55".

Geological formation: Lower Coal Measures. Probably the Ganister or Lower Mountain Mine Fireclay and the Lower Foot Mine Fireclay.

The measurements of the winding-shaft are approximately as follows:—

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Measures	25	2	25	2
Sweet Coal [?Ganister or Lower Mountain Mine]	1	10	27	0
FIRECLAY, working, about	6	0	33	0
Measures	36	1	69	1
Stone Mine Coal [?Lower Foot Mine]	11		70	0
FIRECLAY (the Drab Clay), working, about	6	0	76	0

The Sweet-Coal Fireclay is made up of the following:—

	Ft.	In.
'Ganister' in impersistent patches	4	to 6
'Fireclay'	1	8
'Silica-rock'	4	4

The pillars of Sweet Coal, left by the old men, are being worked, as well as the Sweet Coal Fireclay and the Drab Clay.

The two fireclays are kept separate, as they differ in quality and are used for different classes of goods.

The Sweet Coal Fireclay is used for highly-refractory goods and is ground down in bulk—i.e., the 'fireclay' and the 'silica-rock' are used in their natural proportions, and form a blend which is suitable for the goods required—viz., cupola lining-lumps, brass-furnace linings, gas-furnace crowns and all such high-temperature wares.

The Drab or Stone Mine Clay is used for common firebricks, boiler-seatings and glazed sanitary ware.

The 'ganister' that overlies the Sweet Coal Fireclay is used as an ingredient in the mixture for special high-temperature goods, and is also sold as ground wet ganister for lining cupolas.

Reserves: The general dip of the measures is north-west at 1 in 6 or 7. The beds rise to the south-east, and the Sweet Coal and its underclay may crop out a few hundred yards away in that direction. There are plenty of reserves to the north-east. About a quarter of a mile to the west the Coal Measures are cut off by the faulted margin of the Trias.

Mode of working: Pillar-and-stall. The beds are a little troubled by faults. Water drains away into old dip-workings in the coal to the north-west. The roofs of the Sweet Coal and the Stone Mine Coal being loose and shaly require much timbering.

The clays are carried in tubs on rails to the Macclesfield Canal, 300 or 400 yards away, and thence go by boat to the works at Dukinfield, 13 miles or so to the north.

Treatment: About 60 tons of raw clay are carried per week by canal from the mine to the works, where the clays are weathered; but there is so little iron, and that merely as a staining on joint-faces, and so small an amount of alkalies, that it is thought little or no weathering is necessary. The Sweet Coal Fireclay, especially that from the old bords or stalls, has been largely weathered underground, the overlying coal having been gotten by the old men several centuries ago.

The only grog used consists of burnt brick-waste.

Ground ganister is prepared from the 'ganister' above the Sweet Coal clay, and from best fireclay mixed with a suitable proportion of a siliceous rock from elsewhere.

WILLIAM HAMMOND, LTD.

Firebrick Works, Pott Shrigley, near Macclesfield.

Works: Brickworks at Pott Shrigley, 4 miles N.N.E. of Macclesfield. Established 1849.

Mines: Clays obtained from (1) the Moorside Pit, a shaft situated several hundred yards west of the works, and (2) the Tunnel Level, about the same distance east of the works.

Maps: One-inch New Ser. Ordnance 98, Old Ser. Geological 81 N.W.; six-inch Cheshire 29 S.W.

Moorside Pit: Latitude $53^{\circ} 18' 52''$. Longitude $2^{\circ} 4' 30''$.

Tunnel Level: Latitude $53^{\circ} 18' 47''$. Longitude $2^{\circ} 4' 12''$.

The works and mines are all close together in a valley (Bakestone Dale), half-a-mile north-east of Pott Shrigley Church.

Geological formation: Lower Coal Measures. Probably the Ganister or Lower Mountain Mine Coal.

The section of the Moorside Pit is as follows, in abstract:—

	Thickness.			Depth.		
	Yds.	Ft.	In.	Yds.	Ft.	In.
Rock and shale	60	0	0	60	0	0
Great Smut Coal [Upper Mountain or 40-yards Mine]	1	6		60	1	6
Fireclay (not yet worked)	4	0		61	2	6
Rock and shale	53	0	0	114	2	6
Little Smut Coal [Upper Foot Mine]		8		115	0	2
Rock and shale (firm)	17	0	0	132	0	2
Sweet or Shore Coal (working) 1 ft. 8 in. to	1	10		132	2	0
SWEET SEAM FIRECLAY (working) 3 ft. 6 in. to	4	0		134	0	0

The details of the Sweet Coal fireclay are as follows:—

	Ft.	In.
'Ganister,' 6 in. to	1	0
Best fireclay	1	6
Seconds fireclay	1	6

The measures dip a little north of west at 1 in 6 or 7. A north-and-south fault with westward downthrow of 30 yards crosses the ground between the shaft and the level. There are a few trifling faults in the workings, but these give little or no trouble. Water in the deep workings is pumped part way up the shaft and turned into a tunnel, by which it flows to an old shaft and thence goes out by an adit to Bollington.

Mode of working: The fireclay is got mostly from the shaft, a smaller quantity being obtained from the level. The clay and coal are worked by the pillar-and-stall method. In the level the bulk of the coal was worked out by the old men. The coal-pillars are now being removed with the clay, and the latter is in a good weathered condition through the passing of air and water and the swelling of the floor in the old coal workings.

Reserves: There are tips of fireclay at the shafts amounting (in Sept., 1916) to 5,000 tons. There are large reserves underground.

Treatment: The clay from the pit is weathered as long as possible. That from the level is already sufficiently weathered. A small quantity of the 'best' clay (*i.e.*, from the upper half of the bed) is supplied raw to one of the glass-works at St. Helens. The remainder is mixed with the 'seconds' and used by Messrs. Hammond for their products. New unweathered clay is avoided for the larger-sized goods so as to prevent cracking during the drying.

The ganister that forms the top band of the Sweet Coal fireclay is now being used in the production of a high-temperature brick called the 'Special H Brick.' This brick is said to have proved satisfactory for the roofs of steel-furnaces. The only grog used consists of old burnt bricks.

A siliceous firebrick is being made experimentally from a mixture of 'best' fireclay and a siliceous sandstone. This sandstone is quarried on the northern side of the valley, between the pit and the factory, where a large face of rock is exposed and plenty of reserves are to be obtained. The sandstone is said to be identical

with or similar to one formerly used for the bakestones on which it was customary hereabouts to bake oat-cakes and bread. The custom gave the name Bakestone Dale to the valley. The siliceous firebricks, which are of a reddish colour and somewhat soft, are branded '6.'

R. E. KNOWLES

Furness Vale Colliery and Fireclay Works,
Furness Vale, Stockport.

Works: Works in Furness Clough, on west side of the Buxton road, $\frac{1}{8}$ mile west of Furness Vale Station (L. & N.W. Rly.), 4 miles north-west of Chapel-en-le-Frith.

Mine: Clay obtained from a level a few yards west of the works.

Maps: One-inch New Ser. Ordnance 99; one-inch Old Ser. Geological 81 N.W., six-inch Cheshire 20 S.E.

Latitude $53^{\circ} 20' 50''$. Longitude $1^{\circ} 59' 35''$.

Geological formation: Lower Coal Measures. Fireclay under the White-Ash or Half-Yard Coal.

The position of the coal and clay is shown by the following section of a disused shaft (No. 1 Shaft) situated at the mouth of the level and a few yards west of the works.

					Thickness.	Depth.
					Ft. In.	Ft. In.
Shale	...	...	...	...	79 0	79 0
Red-Ash Coal	...	...	...	1 ft. to	1 6	80 6
Fireclay (inferior, not worked)	...	...	...	...	25 0	105 6
Rock	...	...	...	...
Shale	...	...	...	...	45 0	150 6
White-Ash Coal	...	...	...	9 in. to	1 0	151 6
WHITE ASH FIRECLAY	...	...	...	...	3 0	154 6

Below these measures follow:—

				Ft. In.
Shale, about ...	...	...	...	27 0
Ganister Coal	}	93 to 108 ft., say		100 0
Ganister Fireclay				
Measures				
Big Mine Coal.				

The Red-Ash Coal, the White-Ash Coal, and the White-Ash Fireclay are all being worked. The Ganister Fireclay is worked occasionally.

The 'level' or day-eye is a cross-measure drift, which enters the ground in a south-westward direction and descends in the measures. These dip about E. 30° N. at 1 in 5 or 6.

Reserves: There are ample reserves, especially in a southerly and south-westerly direction. The tips of clay at the surface are small, owing to shortage of labour.

Mode of working: The mine is worked on the pillar-and-stall system, first by a whole working, then by broken working. There are no serious troubles from faults, and the water issues at the day-eye.

Treatment: The clay is weathered as long as possible. The whole of the clay is good, but the upper 2 ft. are the better

quality. Nodules of clay-ironstone, about 3 in. in diameter, which are present throughout the clay, but especially towards the base, are picked out at the tips.

The grog used consists of ground firebrick. For special goods a local sandstone ('firestone') is used as a grog.

The firestone is a brownish-yellow sandstone obtained from a large old quarry on the western side of the Buxton road about 300 yards south of the cross-roads near Furness Vale Station. The quarry is engraved in the six-inch maps of Cheshire, Sheets 20 S.E. and 29 N.E. Lat. $53^{\circ} 20' 41''$. Long. $1^{\circ} 59' 10''$.

The quarry shows a face about 25 ft. high, in which the dip is about E. 20° N. at 10° . The beds are cut into flags by a diagonal structure. There are large reserves of the rock.

South-East Lancashire.

THOMAS SHAW (OLDHAM), LTD.

Lowside Brickworks, Glodwick, Oldham, and Besom Hill, Moorside, Oldham.

The firm have two works, one at Lowside, where red goods alone are made, the other at Besom Hill, Moorside, Oldham. The following particulars refer to the latter.

Works and Quarry: Works at Besom Hill, 3 miles N.E. of Oldham. Openworks adjacent to works.

Maps: One-inch New Ser. Ordnance 85, one-inch Old Ser. Geological 88 S.W.; six-inch Geological Lancashire 89 S.E.

Latitude $53^{\circ} 34' 13''$. Longitude $2^{\circ} 3' 45''$.

Geological formation: Lower Coal Measures. Lower Mountain Mine Fireclay.

The following is an approximate estimate of the beds exposed in the quarry-face:—

	Ft.
Shale, hard, dark-grey (working for red goods) ...	60
Rock (used with the fireclay below for firebricks) ...	1
LOWER MOUNTAIN MINE FIRECLAY (used for firebricks)	7
Shale (used for red goods), seen for	9
	<hr/>
	77
	<hr/>

The face of the quarry forms a high vertical cliff on the northern end of Besom Hill, and the beds are apparently flat. The Lower Mountain Mine or Ganister Coal, which should immediately overlie the fireclay, appears to be absent. The Upper Foot Mine coal, which is said to overlie it at about 36 to 45 ft. higher, should cross the upper part of the cliff, but nothing was seen of it.

The fireclay could be worked by a level driven from the outcrop. At present the firm's main output is red bricks, made from the overlying shales, of which a large mass has to be brought down before an appreciable quantity of fireclay can be obtained.

Reserves: There appear to be ample reserves underground to the south.

Treatment: The clay is put aside till enough has accumulated, and is thus to some extent weathered. At the time of our visit (Sept., 1916) no firebricks were being made.

The grog used consists of waste firebricks.

WILLIAM DRANSFIELD & SONS.

Besom Hill Brickworks, Moorside, Oldham.

At these works the firm are making red bricks, but no fireclay goods at the present time owing to scarcity of labour. The works are situated a few yards west of Messrs. Thomas Shaw's establishment (p. 51), and the geological conditions are similar, with the difference that here the Lower Mountain Mine Coal is 18 in. and the underlying fireclay 3 ft. 6 in. in thickness.

The coal and fireclay are got by a day-level. The firm have long supplied firebrick goods to local ironfounders for furnace work.

THE PIONEER BRICK & TILE CO., LTD.

Grotton, Lees, Oldham.

Works: Works at Thornley, $\frac{3}{8}$ mile south of Grotton and Springhead Station (L. & N. W. Rly.), 2 miles east of Oldham.

Clay-pit: Openworks adjacent to the works.

Maps: One-inch New Ser. Ordnance 85, Old Ser. Geological 88 S.W.; six-inch Lancashire 97 S.E.

Latitude $53^{\circ} 31' 45''$. Longitude $2^{\circ} 3' 5''$.

Geological formation: Millstone Grit. According to the Geological Survey map the beds belong to the Third Grit, Top Bed, and the underlying shales of the Millstone Grit. The Ganister Coal crops out some distance west of the openworks. The beds are exposed immediately south of the works, in a long face nearly parallel to the strike and in a shorter face at right-angles and parallel to the dip, which is W. 10° N. at about 1 in 3 (20°).

The following section was measured on 23rd Sept., 1916:--

	Ft.	In.
1. VICTORIA FIRECLAY, covered by slipped drift, rubble and wash, said to be	4	6
2. Sandstones, soft, rubbly, iron-stained, passing upward into 1, about	5	0
3. Upper Ganister bed: pale-yellow sandstone with micaceous films; grey where unweathered ...	6	0
4. Coal (not named), 11 in. available as fuel ...	1	6
5. Fireclay, about	1	6
6. Clay, grey, with small ironstone-nodules ...	1	0
7. Sandstone, soft, iron-stained and grey ...	2	0
8. Shales, soft, black, estimated at about ...	10	0
9. Lower Ganister Bed, forming a conspicuous band on the long face of the quarry	5	0
10. SHALES, dark-grey, with a few small ironstone-nodules; thickness estimated at 100 ft. at southern end of face, where the lowest beds are being worked	100	0
	136	6

At the time of our visit (Sept., 1916) no refractory goods were being made; but the crop of the Victoria Fireclay was being cleared for the driving of a slant by which the clay could be worked. Hitherto, when firebrick goods have been undertaken, the raw material has been purchased and supplemented with clay dug from the crop of the Victoria Fireclay.

The shales (10) are quarried for the red goods that constitute the main output of the works.

The ganister has been used as grog for special fireclay goods; the usual grog consists of old firebricks.

Reserves: There are presumably ample reserves of the Victoria Fireclay west of the outcrop.

J. & S. ROTHWELL, LTD.

Doffcocker Fireclay Works, Bolton.

Works and Mine: Works at Delph Hill, Doffcocker, $2\frac{1}{2}$ miles N.W. of Bolton. Two shafts adjacent to the works.

Maps: One-inch New Ser. Ordnance 85, Old Ser. Geological 89 S.E.; six-inch Geological Lancashire 86 S.E.

Latitude $53^{\circ} 35' 30''$. Longitude $2^{\circ} 28' 53''$.

Geological formation: Lower Coal Measures. Lower Mountain Mine Fireclay.

The shaft-section is said to be as follows:—

						Ft. In.
Made ground	...	...	...	...	...	33 0
Rock and metal	...	...	...	...	...	134 5
Lower	{	Little Coal (working)	9 in. to	...	...	10
Mountain		FIRECLAY (working)	5 ft. 3 in. to	...	...	5 9
Mine.		'GANISTER' (working)	18 in. to	...	...	2 0
		Coal (working)	14 in. to	...	...	1 4
Rock bottom [? Ganister]	...	...	...	...	...	—
						<hr/> 177 4 <hr/>

The 'ganister,' which is a hard grey fireclay, is said to lie between the fireclay and the lower coal. According to Dr. E. Hull¹ there is a considerable thickness of 'hard ganister rock' under the lower coal.

Mode of working: Pillar-and-stall. The coal having been got by a first working by the old men, what is now raised is obtained from the pillars that were left. The fireclay has thus been considerably weathered underground. Of the fireclay and ganister, which together amount to about 7 ft. in thickness, 4 ft. are worked, and the remainder left below to stow the gob.

Water makes its way into old workings and thence drains away by an adit to the nearest river.

Reserves: There are ample reserves underground, but the tips on the surface are small owing to lack of labour.

Treatment: The clay is weathered as long as possible in normal times.

The 'ganister' has been occasionally sold in the lump to local iron foundries, but has not yet been used by the firm for any of their products.

¹ 'The Geology of the Country around Bolton-le-Moors' (*Mem. Geol. Surv.*), 1862, p. 6.

JAMES OAKES.

Croal Brickworks, Farnworth, Bolton.

Works and Claypit: Works by side of the river Croal, $\frac{1}{2}$ -mile north of Farnworth Station (L. & Y. Rly.), 2 miles S.E. of Bolton. Openworks adjacent.

Maps: One-inch New Ser. Ordnance 85, Old Ser. Geological 89 S.E.; six-inch Geological Lancashire 95 N.W. and N.E.

Latitude $53^{\circ} 33' 15''$. Longitude $2^{\circ} 22' 50''$.

Geological formation: Middle Coal Measures. Two fireclays at or near the horizon of the Worsley Four-Foot Coal.

The openwork is a large excavation on the western bank of the Croal, immediately east of the cemetery. It shows a long succession of clays, shales and sandstones, with two fireclays, all dipping S. 20° W. at about 30° . The lower fireclay, 2 to 3 ft. thick, crops out at the north-eastern end of the excavation, below the works. The upper fireclay is 1 ft. to 1 ft. 6 in. thick, is overlain by a thin coal, and crops in the bottom of the excavation, not far from the south-western face, where the ordinary clays and shales are being dug for red goods, the main output of the works.

Reserves: The two fireclays presumably continue underground to the dip, and could be worked by slants; but it is doubtful if this would pay unless the fireclays prove to be of high quality.

The fireclay forms a subsidiary item among the other material. As far as possible it is put aside when the course of the work brings it under the pick, and when sufficient has accumulated it can be used for any ordinary refractory goods required.

Method of working: The clays, shales and sandstones are worked for red goods as an open quarry. Blasting is occasionally needed. Water drains into the river Croal, the present floor of the quarry being about 10 ft. above river-level.

JOHN SCHOFIELD.

Thurston Clough Coal and Fireclay Mine, Delph, near Oldham.

Mine: There are no works. The fireclay is obtained from two day-levels on west side of the main Manchester and Huddersfield road, $\frac{5}{8}$ -mile S.W. of Delph Station (L. & N. W. Rly.).

Maps: One-inch New Ser. Ordnance 86, Old Ser. Geological 88 S.W.; six-inch Yorkshire 270 N.E.

Latitude $53^{\circ} 33' 28''$. Longitude $2^{\circ} 1' 57''$.

Geological formation: Lower Coal Measures. Two fireclays under the Lower Foot Mine Coal.

The following table shows the general sequence:—

	Ft.	In.
Lower Mountain or Ganister Mine (has been worked in the vicinity)	—	—
Measures, about	30	0
Shale roof (with <i>Pterinopecten papyraceus</i>)	—	—
Lower Foot Mine Coal	10	—
FIRECLAY (opening up), said to be	6	0
Grit and sandstone, believed to be	10	0
Holing dirt (coal and clay interbedded)	1	6
Coal, called No. 2	—	5
FIRECLAY, black at top, grey below, (working)	4	6
Bin-dirt (grey clay)	—	—

The two levels are about 100 yards apart, in a north-and-south line. The northern level is in the No. 2 Coal and fireclay, and from it the No. 2 fireclay was being worked. The southern level, at a somewhat higher altitude, was being driven in search of the Lower Foot Mine Fireclay, but owing to a westward downthrow fault that crosses the level a quantity of grit and sandstone has to be traversed.

The beds dip about S.S.W. at 2 or 3 in. per yard. Water escapes by the level. The No. 2 clay, which is worked on the pillar-and-stall system, is sold in the lump to various Lancashire firms of firebrick makers, and to foundries in the Oldham district.

RICHARD BERRY, LTD.

Smethurst Hall Brickworks, Jericho, Bury.

Works and Mine: Works on east side of Rough Hill Lane, Jericho, on the Rochdale road, $1\frac{1}{2}$ miles E.N.E. of Bury.

Fireclay raised from a drift at the bottom of an open claypit adjacent to the works.

Maps: One-inch New Ser. Ordnance 85, Old Ser. Geological 88 S.W.; six-inch Geological Lancashire 88 N.W.

Latitude $53^{\circ} 36' 7''$. Longitude $2^{\circ} 15' 23''$.

Geological formation: Lower Coal Measures. Lower Foot Mine Fireclay.

The general section of the measures is as follows:—

	Ft. In.
Shale (worked in the open clay-pit for red goods)	—
Lower Foot Mine Coal 10 in. to	1 0
FIRECLAY (working) 4 ft. to	6 0
Shale, hard	15 0
Three-Quarters or Feather-Edge Coal	2 2
Rough Rock (Millstone Grit)	—

The Lower Foot Mine Coal—or what remains of it in the old coal-workings—is left to support the roof. The Three-Quarters Coal left by the old men is not worth getting.

The uppermost 6 in. of the fireclay is darker than the rest, but the whole of the clay is brought out and worked up together for firebrick goods.

The beds are nearly horizontal, or dip gently southward.

Reserves: There are ample reserves underground to the west of the present claypit.

Method of working: Pillar-and-stall.

Treatment: The whole of the fireclay is ground up together.

For common firebricks the grog used consists of old firebricks. For high-temperature goods it is proposed to use in addition crushed sandstone from the Rough Rock of the Millstone Grit, which crops out at Gallows Hill, a quarter of a mile to the north, where it is crushed for moulding-sand and furnace-hearth sand by Mr. John Crook at the Church Quarry, Birtle. Common red bricks are the main product, the firebrick goods being a subsidiary line; ground fireclay is sold.

CHAPTER VI.

NORTH-EASTERN DISTRICT.

NORTHUMBERLAND AND DURHAM.

A large amount of fireclay brick is made, but comparatively little of this is sufficiently refractory for use in blast or steel furnaces. A certain amount of such firebrick is manufactured for blast-furnaces and the outer parts of steel-furnaces; but much more is made for coke-oven linings, gas works, boiler-settings and fire-grates; while a large proportion of the fireclay raised is utilized for making sanitary ware.

The greater part of the more refractory firebrick used in the district is brought from elsewhere.

Apart, however, from the manufacture of firebrick exclusively from fireclay, a considerable amount of fireclay is mixed with ganister and silica-rock for making clay-bond ganister-brick. Fireclay is also used, either alone or mixed with ganister or silica-rock, as pug-ganister, for setting firebricks, etc. Both these uses of fireclay are described in Vol. VI of this series of Reports.

The lower part of the Middle Coal Measures and the Lower Coal Measures contain several good fireclay-seams ("seggars"), mostly constituting the underclays of coals. A few fireclays are obtained from the Carboniferous Limestone Series. It is almost entirely from the Coal-Measure clays that the more refractory firebrick is made, the clay-seams being raised mostly in conjunction with the associated coals.

Tyneside is the chief centre of the firebrick industry in the north-eastern district, but produces the less highly refractory grades of firebrick. The more refractory firebrick is made in Weardale and elsewhere in the coalfield at a few large collieries, which employ the fireclay raised in working the coals.

The following table gives in descending order the more refractory fireclays used and their positions in the Middle and Lower Coal Measures, the names of the more important clays being printed in capitals, others in italics:—

					Thickness.
					Ft. In.
Middle Coal Measures (lower part)—					
Bottom Harvey. Tilley or Constantine Coal					
1 ft. 6 in. to	...	...	...	...	1 8
CONSTANTINE FIRECLAY	...	...	...	...	3 9
Measures	...	...	...	about	63 0
Top Busty or Ballarat Coal	...	...	1 ft. 10 in. to	4	6
BALLARAT FIRECLAY	...	...	1 ft. 8 in. to	5	0
Measures	...	...	10 ft. to	13	0
Five Quarter or Bottom Busty Coal	...	...	...	3	0
<i>Fireclay</i>	...	...	...	...	10
Measures	...	...	5 ft. to	47	0

						Thickness.
						Ft. In.
Middle Coal Measures (lower part)— <i>continued</i> —						
Busty, Bottom Busty, Three Quarter or B Coal						
					8 in. to 1	8
B. FIRECLAY	...	...	...	...	...	2 0
Measures	...	...	...	...	...	29 0
Top Brockwell or Top Main Coal	...	...	...	...	2 ft. to 5	8
<i>Fireclay</i>	...	...	...	...	1 ft. to 1	10
Measures	...	...	...	...	9 ft. to 17	0
Brockwell, Bottom Brockwell or Main Coal						
					3 ft. 2 in. to 4	0
Lower Coal Measures—						
FIRECLAY	...	...	...	...	1 ft. 4 in. to 6	0
Measures	...	...	...	...	...	46 0
Victoria Coal	...	...	...	...	6 in. to 1	1
FIRECLAY (? WITTON FIRECLAY)	...	...	...	...	2 ft. 9 in. to 4	4
Measures	...	...	...	...	...	85 0
Marshall Green Coal	...	...	...	...	1 ft. 1 in. to 4	4*
<i>Fireclay</i>	...	...	...	...	...	10
Measures	...	...	...	...	...	74 0
Tow Law Ganister	...	...	...	...	3 ft. to 4	0
<i>Fireclay</i>	...	...	...	...	...	1 0
Measures	...	...	...	...	...	? 6 0

Millstone Grit:—No refractory clays obtained.

* Locally in two beds with *Fireclay* 2 ft. 4 in. in middle.

(The above table probably contains all the more refractory Coal-Measure clays used, though one or two, worked under local names, have not been identified with certainty.)

		Approximate distance in feet below Millstone Grit.
Carboniferous Limestone Series—		
Calcareous Group (Upper part)	Shales, sandstones, etc., with Fell-top Limestone at about	100
	Shales, sandstones, etc., at the base:—	
	Limestone (about 8 ft.)	350
	FIRECLAY (Corbridge)	
	Shales, sandstones, etc., with limestones, a few coal-seams, and a <i>Fireclay</i> (Haltwhistle) at	500
	Shales, with Little Limestone at	800
	Shales, with Chirm or Rothbury	
	Coal at	820
	Sandstones, shales, etc., with	
	Main or Great Limestone ... at	900

SOUTH TYNE COLLIERY & FIREBRICK CO., LTD.

Haltwhistle.

Situation: The colliery at which firebrick was made is at the north-east end of the town, on the south-east side of the main road, and on the south-west bank of the Haltwhistle Burn.

Maps: One-inch New Ser. Ordnance 19, Old Ser. Geological 106 S.E.; six-inch Northumberland 91 N.E.

Latitude 54° 58' 15". Longitude 2° 26' 55".

Geological formation: Carboniferous Limestone Series.

The Company ceased to manufacture refractory brick some years ago and have now given up making even common brick.

They used to make firebricks from a good-looking fireclay about 3 ft. thick, obtained from their collieries at a horizon said to be about 300 ft. above the Little Limestone, in the Calcareous Group of the Carboniferous Limestone Series, which is thicker here than farther south and south-east.

Reserves: Probably abundant.

LANGLEY BARONY COAL & FIRECLAY CO., LTD.

Langley-on-Tyne.

Works: Close to and on south side of Langley Station.

Mine: Stublick Colliery, $\frac{3}{4}$ -mile south-east of the works.

Maps: One-inch New Ser. Ordnance 19, Old Ser. Geological 106 S.E.; six-inch Northumberland 93 S.W.

Latitude (Stublick) $54^{\circ} 56' 28''$. Longitude $2^{\circ} 12' 53''$.

Geological formation: Middle and Lower Coal Measures.

The Langley Barony Company make firebrick only for their own use in constructing ovens for their sanitary ware, the manufacture of which is the principal business of their fireclay works.

For both firebricks and sanitary ware they use regularly two and sometimes a third fireclay, all obtained from their own colliery, one of the clays regularly used being the underclay of the Yard Coal (lower part of Middle Coal Measures), the highest seam worked at the colliery. It is probably the equivalent of one of the higher seams in the table on p. 56. The other two seams lie somewhat lower.

These fireclays are mixed together for making both firebrick and sanitary ware, the only difference being that no grog is added for firebrick, but that burnt clay is added for sanitary ware.

W. & J. J. WALKER.

The Pottery, Corbridge-on-Tyne.

Works: Rather more than a mile north of Corbridge Station, and about 200 yards W.S.W. of claypit.

Pit: One and a quarter mile N.N.E. of Corbridge Station.

Maps: One-inch New Ser. Ordnance 20, Old Ser. Geological 105 S.W.; six-inch Northumberland 95 N.W.

Latitude $54^{\circ} 58' 58''$. Longitude $2^{\circ} 0' 20''$.

Geological formation: Carboniferous Limestone Series (Calcareous Group)—probably about 250 ft. below the Fell-top Limestone and not far above a coal seam (Stanton ? Coal).

The claypit shows the following section:—

	Pt.
'Cover' { Blue limestone about	3
{ Weathered yellow shaly clay about	1
Blue, red-jointed saponaceous fireclay, not shaly, with a somewhat sheared appearance	5-6
Carbonaceous, micaceous and sandy dark shale ('black plate')	...

A coal, probably the Stanton Coal, is stated to have been worked in the neighbourhood at a very little depth below this fireclay. The blue limestone, said to have a complete thickness

of 7 or 8 ft., is seen to underlie a thicker sandstone in a quarry a little farther north-east, near Messrs. Jameson's Brickworks, at which apparently the same fireclay is worked, though slightly different in character.

The fireclay of Messrs. Walker's pit is fine-grained, smooth and saponaceous in texture, and soft but tough. It is regarded as of uniform quality throughout its thickness. The red colour along joints is due to surface staining.

This clay is used for making firebricks and gas-retorts.

Reserves: Appear to be adequate for Messrs. Walker's purposes. Messrs. Walker have another claypit about 200 yards south of the above, but do not themselves use the clay there worked, which, to judge by the slight southerly dip and the somewhat greater southward slope of the ground, lies at a rather lower horizon than their own clay.

Treatment: All the clay used is obtained from the claypit first described. For making firebrick it is ground, but not very fine. No burnt firebrick or other grog is added, and the little white pellets seen in the brick are said to be merely the coarser fragments of the fireclay.

For making gas-retorts and 'quarls' a considerable amount of grog is added. This mixture is said to stand a great heat. The same mixture, however, is used for fire-backs and hearth-stones. All manufacture is apparently done by hand.

Boulders of a fine-grained, pinkish sandstone found upon, and, it is said, even forced under, the outcrop of the limestone that overlies the fireclay, are crushed to make sand for dusting the raw firebricks. The sand is a pinkish quartzose sand.

Products: Firebricks for coke-ovens, etc., gas-retorts, 'quarls' (oblong slabs), hearth-stones and fire-backs, sanitary-pipes and troughs. Messrs. Walker do not now make silica-brick, but they used to make it apparently on a small scale, and they obtained their ganister from Dipton, S.W. of Corbridge, from a bed of ganister, or more probably silica-rock in the Millstone Grit Series. This bed is no longer worked.

The clay obtained from the second claypit (see above) but not used by Messrs. Walker themselves, is regarded as a stronger clay. It is supplied for making saggars and crucibles for pottery; it is also supplied in a 'pugged' state, with admixture of 'grog' of firebrick made from Messrs. Walker's own clay for 'pottery crucibles.'

PEASE & PARTNERS, LTD.

Bankfoot Brickworks. Crook.

Roddymoor and other mines.

Situation: Brickworks, north of the Station at Crook.

Mines working fireclay:—

Bowden Close, Willington.

Esh, Durham.

Roddymoor, Crook.

Ushaw Moor, Durham.

Maps: One-inch New Ser. Ordnance 26 and 27, Old Ser. Geological 103 N.E.; six-inch Durham 26, 27 and 34.

Geological age: Lower part of Middle or top of Lower Coal Measures.

Messrs. Pease & Partners now use only one fireclay, known as the Roddymoor Clay Seam, from their own mines. But they have also in their pits and have at times used, other fireclays known locally as the 'A,' 'B,' Ballarat and Five-Quarter Seams. All these, so far as they can be identified, are in the lowest beds of the Middle Coal Measures (*see table, p. 56*).

Reserves: Evidently abundant.

Products: (a) The chief product is 'second silica-brick,' made entirely of ganister or silica-rock, with lime bond; it is classed as a 'ganister' brick and is used in iron- and steel-works.

(b) Special quality fireclay goods, made of silica-rock and two local clays; sold for coke-ovens, producer-linings, etc.

(c) Common firebrick for producer-linings, boiler-settings, etc.

(d) Sulphuric acid bricks for Wedge and Herreschoff furnaces.

(The silica-rock is all purchased from quarries in the district.)

PICKFORD, HOLLAND & Co.

Crook, Co. Durham.

Quarries: Bounder House Quarry and others near Tow Law.

A fireclay (1 ft. thick) underlying the Tow Law ganister (base of the Lower Coal Measures) (*see table, p. 57*) is worked with the ganister at these quarries and is used by the firm at Crook to mix with ganister for ladle and cupola lining.

For details of the quarry *see* 'Special Reports on the Mineral Resources of Great Britain,' vol. vi, Ganister, etc., Ed. 2, 1920, p. 48.

NORTH BITCHBURN COAL CO., LTD.

Victoria Road, Darlington.

North Bitchburn & Rough Lea Mines.

Situation: Works at North Bitchburn Colliery, North Bitchburn (Beechburn), Crook, and Rough Lea Colliery, near Willington.

Maps: One-inch New Ser. Ordnance 26, Old Ser. Geological 103 N.W.; six-inch Durham 34 S.W.

(N. Bitchburn) Latitude $54^{\circ} 41' 15''$. Longitude $1^{\circ} 44' 0''$.

(Rough Lea) „ $54^{\circ} 41' 44''$. „ $1^{\circ} 42' 5''$.

Geological formation: All three of the clays used are from the lower part of the Middle Coal Measures, above the Brockwell Coal (*see table, p. 57*).

The fireclays used are the underclays of the 'Top' or 'Top Main,' a few feet above the Main or Brockwell Coal, and the 'Constantine' Coals; also at Rough Lea the underclay of the

Ballarat Coal. The fireclays are all obtained from the Company's own Collieries. The underclay of the Constantine Coal is regarded as the best, that of the Ballarat is also a very good fireclay. The Constantine Clay contains a band of ironstone which is picked out. The North Bitchburn Company do not use the full thickness of any of these clays. As is the case with other colliery companies, their only reason for making firebrick at all is to use up a waste product of coal-mining. Consequently only so much of each clay-seam is worked as is necessary to facilitate the working of the coal, *i.e.*, from 1 ft. to 2 ft. 6 in. or rarely 3 ft., whereas the full thickness of the fireclay may be 5 ft.

Reserves will evidently be abundant so long as the associated coal-seams are worked. At the Rough Lea Colliery a waste-heap of many thousands of tons of fireclay is now being used up in this way.

Treatment: The fireclays are mixed indiscriminately as they are got out, and the same mixture is used for both firebrick and sanitary ware.

The clay is preferred in a weathered state, because easier to work; it is more plastic in that state and probably gives a better texture to the finer ware. No ganister is used.

Firebrick is made both by hand and by machinery.

THE WITTON FIREBRICK CO.

Slotburn Brickworks, Wear Valley Junction.

Quarries: Marshall Green Colliery and Witton Fireclay Mine, Witton-le-Wear.

Maps: One inch New Ser. Ordnance 26, Old Ser. Geological 103 N.W.; six-inch Durham 33 S.E.

Marshall Green Colliery. Latitude $54^{\circ} 40' 35''$. Longitude $1^{\circ} 46' 5''$.

Geological formation: The Witton Fireclay, the only clay used, is obtained from the Lower Coal Measures, at a distance of about 150 ft. above the base (*see table, p. 57*).

It is a tough siliceous and saponaceous fireclay containing bullions of harder fireclay, which are used with the softer clay, and ironstone nodules, which are rejected. Thickness 2 ft. 9 in.

Reserves: Large.

Mode of working: The fireclay is mined by drift at the Company's own colliery and fireclay mines, where the overlying coal is got with the clay and is used at the works, as it is of fair quality though only 7 in. thick.

Treatment: The clay is roughly hand-picked at the mines and again more thoroughly at the works, to get rid of ironstone-nodules and other impurities.

It is allowed to weather as far as possible.

After grinding, etc., the clay is used for making 'No. 2 Ganister Brick,' used for coke ovens, and is sold as 'ground clay.'

GRAYSON LOWOOD & Co., LTD.

Middlesbrough.

Quarries: Castleton, North Cleveland.

A sticky and plastic siliceous clay, of a thickness varying up to 6 ft., irregularly overlies the silica-rock of Castleton and Commondale at Castleton. It occurs at the base of the Upper Estuarine Series (Inferior Oolite, Jurassic), immediately above the silica-rock (Moor Grit).

This silica-clay is supplied in small quantity for use as 'puganister,' for 'botting' furnaces, etc.

For details of the quarry, *see* 'Special Reports on the Mineral Resources of Great Britain,' vol. vi, Ganister, etc., Ed. 2, 1920, p. 42.

ADAMSEZ, LTD.

Scotswood-on-Tyne.

Scotswood Mine.

Situation: The works and mine are situated on the north side of the Tyne, just above the Scotswood suspension bridge.

Maps: One-inch New Ser. Ordnance and Geological 20, (= Old Ser. Geological 105 S.W.); six-inch Northumberland 97 N.W.

Latitude $54^{\circ} 58' 5''$. Longitude $1^{\circ} 41' 29''$.

Geological formation: Coal Measures.

The material worked for sanitary ware is the seat-earth of the Lister Seam, which consists of 6 to 10 in. of coal resting on about 2 ft. of fireclay. The Low Main Coal, 30 to 40 fms. below the Lister Seam, is also worked.

Reserves: Extensive.

The Lister Seam clay is used mainly for sanitary ware which before the war was the chief product of the firm. Since the war the manufacture of refractory goods has been undertaken, using the Brackleheugh clay (*see* p. 233) as a basis and the Lister Seam clay as a binder. Bricks and blocks for furnaces of several types are now being made.

JAMESON & SON, LTD.

Corbridge S.O., Northumberland.

Hook Hill Mine.

Situation: About half-a-mile north of Corbridge, east of Milkwell Lane.

Maps: One-inch New Ser. Ordnance and Geological 20; (= Old Ser. Geological 105 S.W.); six-inch Northumberland 95 N.W.

Latitude $54^{\circ} 58' 55''$. Longitude $2^{\circ} 0' 0''$.

Geological age: Carboniferous Limestone Series.

The fireclay is mined in two drifts. A fault, throwing down the clay eastwards about 20 ft., has caused a considerable inflow of water which necessitates pumping and has stopped work in this direction.

The roof of the mine is a solid bed of limestone from 7 to 8 ft. thick. This bed is probably about 250 ft. below the Fell Top Limestone, and not far above a coal marked on the map and which is probably the Stanton coal. The fireclay seam is 3 to 5 ft. thick. In places where it is too thin, it is necessary to excavate the 'bastard clay' forming the floor, in order to allow space for a tub to get through. The 'bastard clay' is mainly ironstone and has to be carefully kept out of the fireclay.

The clay was said to be a different seam from those worked at Messrs. Walker's pit near by (*see* p. 58), but this is incorrect. The clay at Messrs. Jameson's is less saponaceous, but this is due to a lateral change, the beginning of which is noticed in the mine now described. The limestone forming the roof at Hook Hill Mine is seen at the bottom of an old sandstone quarry on the other (west) side of the buildings, between them and Walker's. Here about 20 ft. of sandstone is seen containing blebs of limestone in the lowest 2 ft., which rests on 6 in. of black shale and this on 4 ft. of limestone, in three beds. The sandstone was worked for building-stone and the limestone for lime.

The seam is immediately underneath the limestone seam in the quarry, so that it must be the same as the upper clay at Messrs. Walker's which is similarly situated. A little farther west the clay crops out from under the limestone.

It is proposed to get rid of the water in the drift by sinking an incline to the limestone on the other side of the fault, so that the water on the upthrow-side may be carried away by the limestone on the downthrow-side.

Reserves: Indefinite. The seam probably extends a long way to the north and east, but its character may vary. The firm proposes to get the clay on the other side of the fault.

The most important branch of the business is the manufacture of sanitary ware and conduits for electric wires. Gas-retorts, chimney-pots, chemical ware and firebricks are also made.

STRAKERS & LOVE.

Newcastle-on-Tyne.

Brandon Colliery, Durham.

Situation: Close to Brandon Colliery Station, $2\frac{1}{2}$ miles south-west of Durham.

Maps: One-inch New Ser. Ordnance and Geological 26 (= Old Ser. Geological 103 N.W.); six-inch Durham 26 N.E.

Latitude $54^{\circ} 45' 5''$. Longitude $1^{\circ} 37' 15''$.

Geological formation: Middle Coal Measures.

The fireclay is obtained from the tip-heap of Brandon C Pit, which is at present closed.

The seams of coal worked in C pit are the Harvey, B [? B Busty], and Brockwell.

Experiments are being made with the fireclays from the B pit, working the Hutton seam, and the A pit working the Ballarat, Busty and Three-Quarter seams.

Reserves : Large.

LAMBTON & HETTON COLLIERIES, LTD.

Newcastle-on-Tyne.

Lambton Firebrick Works.

The firm have a works at Fence Houses, about 6 miles N.N.E. of Durham. Here they make chiefly sanitary ware, but, in addition, firebricks, and they have appliances for making up to 10,000 bricks a day if there was a demand for them.

The clay is got from under the Main Coal at all the firm's collieries (there are 14 working pits in the Home Office List, in all of which the Main Seam occurs). In addition clay is sometimes bought from other firms.

THE PRIESTMAN COLLIERIES, LTD.

Milburn House, Newcastle-on-Tyne.

Works : Blaydon and Garesfield Works.

Mines : Axwell Park, Blaydon Burn, Garesfield Lily, Victoria Garesfield, etc.

Maps : One-inch New Ser. Ordnance and Geological 20; (= Old Ser. Geological 105 S.W.); six-inch Durham 1 and 6.

Geological formation : Middle Coal Measures.

The underclay is obtained from beneath the Five-Quarter, the Three-Quarter and the Brockwell Coals. The last named is the most worked seam now and it affords the largest reserves.

Brick-making is here a by-product of the coal industry.

THE WEST WITTON GANISTER FIREBRICK CO., LTD.

Hunwick, Willington S.O., Co. Durham.

Works : Situated $7\frac{1}{2}$ miles south-west of Durham, opposite Hunwick Station.

Mines : West Hunwick Colliery.

Maps : One-inch New Ser. Ordnance and Geological 26 (Old Ser. Geological 103 N.W.); six-inch Durham 34 S.W.

Latitude $54^{\circ} 41' 30''$. Longitude $1^{\circ} 41' 55''$.

Geological formation : Middle Coal Measures.

Fireclay is obtained from below the Busty Coal. The chief industry is the manufacture of 'ganister' bricks (silica-brick). Most of the clay is sold in the form of pugged and dry-ground clay. A few firebricks are made.

BELL BROTHERS, LTD.

Middlesbrough.

Mine: South Brancepeth, Spennymoor.*Maps:* One-inch New Ser. Ordnance and Geological 26 (Old Ser. Geological 103 N.W.); six-inch Durham 34.*Geological formation:* Middle Coal Measures.

The clays worked are those of the Busty and Yard Seams, each about 1 to 2 ft. thick. They are employed for firebricks, etc. The reserves of good second-class firebrick clay are small.

WM. STEPHENSON & SONS,

Throckley Brickworks, Newburn-on-Tyne.

Mine: Throckley (Maria Pit).*Maps:* One-inch New Ser. Ordnance and Geological 20 (Old Ser. Geological 105 S.W.); six-inch Northumberland 87.*Geological formation:* Middle Coal Measures.

The clays associated with the Hodge and Stone Coal Seams are worked here. The Hodge Clay is 2 ft. to 3 ft. thick; the Stone Coal Clay is 12 to 18 in. The reserves are large, estimated at 10,000 tons. The clays are used for the manufacture of blast furnace lining lumps.

Northumberland.

List of Mines working or having worked Fireclay.

(Qr. in table = Quarter.)

NAME OF MINE.			SITUATION.		COAL SEAMS WORKED.
Ashington	...	...	Morpeth	...	High Main, Main, Yard, 5 Qr., Low Main, Bensham.
Backworth "Blue Bell"	...	...	Backworth	...	Yard and Main Coal.
Backworth "Eccles" & "Maude."	...	...	Backworth	...	Bensham and Low Main.
Benwell "Charlotte"	...	...	Newcastle	...	Brockwell. 5 Qr., Main, Stone.
Broomhill	...	...	Acklington	...	Queen, Top Main, Bottom and Wonder.
Cambois	...	...	Blyth	...	Low Main and Yard.
Earsdon Church	...	...	Backworth	...	Yard, Bensham and Low Main.
East Walbottle	...	...	Ponteland	...	Beaumont.
Elswick "South"	...	...	Newcastle	...	Stone Coal, 3 Qr., Brockwell.
Hartford "Scott"	...	...	Hartford	...	Stone Coal, Plessey, High and Low Main.
Hartford "Daisy"	...	...	Hartford	...	Yard and Plessey.
Hazlerigg	...	...	Newcastle	...	High Main, Main, Low Main, Yard and Beaumont.
Heldon	...	...	Wylam	...	Stone Coal, Main, 3 Qr., Brockwell and Tilley.
Hook Hill	...	...	Corbridge	...	Fireclay Seam.
Langley Fireclay	...	...	Langley-on-Tyne	...	
Millhouse Drift	...	...	Bardon Mill	...	
Montagu Fireclay	...	...	Scotswood	...	Hodge and Stone Coal (closed down).
Montagu Main	...	...	Scotswood	...	Main Coal, Beaumont. 5 Qr., Brockwell.
Morpeth Moor	...	...	Morpeth	...	Brockwell.

NAME OF MINE.			SITUATION.	COAL SEAMS WORKED.
Newburgh	...	...	Acklington	Albert, Queen, Princess, Duke.
Pegswood	...	...	Morpeth	Low Main, 5 Qr., Yard, Plessey and Harvey.
Scotswood	...	...	Newcastle	Lister and Low Main.
Scremerston	...	...	Berwick-on-Tweed	Cooper Eye (Limestone Coal).
Seaton Burn	...	...	Newcastle	Low Main and Yard.
Seaton Delaval	...	...	Newsham	Yard, Bensham, Stone Coal, Low Main, Plessey and High Main.
"Forster."				
Seaton "Hastings"	...	...	Seaton	Yard and Low Main.
Seaton "Relief"	...	...	Delaval	Main Coal and Yard.
Throckley	...	...	Newburn	Engine, Tilley, Stone Coal, Main Coal and Brockwell.
Throckley "Maria"	...	...	Newcastle	Main Coal, Stone Coal, Hodge, Tilley, Engine and Brockwell.
Walbottle	...	...	Lemington-on-Tyne	Engine, 3 Qr., Tilley, Stone Coal Main Coal, Brockwell and Hodge
West Mickley	...	...	Prudhoe	Cannel.
West Wylam	...	...	Prudhoe	Towneley, Yard, 6 Qr., 5 Qr. and Brockwell.
Wrig	...	...	West Cramlington	Main Coal and Yard.

Durham.

List of Mines working or having worked Fireclay.

NAME OF MINE.			SITUATION.	COAL SEAMS WORKED.
Addison	...	...	Blaydon-on-Tyne	Townley, Tilley, Stone Coal, 5 and 3 Qr. and Brockwell.
Auckland Park	...	...	Bishop Auckland	Brockwell and Busty.
Axwell Park	...	...	Swalwell	Stone Coal, 5 and 3 Qr., Beaumont and Brockwell.
Bearpark Brancepeth			Durham	Low Main, Hutton, Harvey and Busty.
Blackhill	...	...	Consett	Busty, 3 Qr., Brockwell.
Blaydon Burn "Mary"			Blaydon-on-Tyne	Barlow Field, 5 and 3 Qr., and Brockwell.
Brancepeth C.	...	...	Willington	Jet, Ballarat, Harvey, 3 Qr.
Bourn Moor	...	...	Fence Houses	Maudlin, Main Coal, Low Main.
"Lady Anne."				
Bowden Close	...	...	Willington	Top Main, Yard, and 5 Qr.
Brandon C.	...	...	Durham	Harvey, B., Brockwell.
Broompark	...	...	Durham	Hutton.
Byer Moor	...	...	Burnopfield	Busty and Brockwell.
Cornsay	...	...	Cornsay	5 Qr., Main Coal, Ballarat, 3 Qr. Harvey.
Craghead George	...	...	Chester-le-Street	
Delves	...	...	Consett	Busty, 3 Qr., Brockwell.
East Hetton	...	...	Coxhoe	Low Main, Hutton, Harvey, and Brass Thill.
East Tanfield	...	...	Stanley	Hutton, Beaumont, Tilley and Brockwell.
Elemore	...	...	Hetton-le-Hole	Main Coal, Low Main, Hutton.
Eppleton "Caroline"	...	...	Hetton-le-Hole	Main Coal, Maudlin and Hutton.
Eppleton "Jane"	...	...	Hetton-le-Hole	Hutton
Esh	...	...	Durham	5 Qr., Main Coal, Ballarat, Harvey and Hutton.
Garesfield "Bute"	...	...	Rowlands Gill	3 Qr., Brockwell, Stone Coal, and 5 Qr.
Garesfield "Lily"	...	...	Rowlands Gill	Barlow Field, Stone Coal, 5 Qr. 3 Qr., Brockwell.
Hamsterley	...	...	Ebchester	Tilley, Townley, Top and Bottom Busty, 3 Qr., Brockwell.

NAME OF MINE.			SITUATION.		COAL SEAMS WORKED.
Hamsteels	...	...	Durham	...	Busty and Harvey, Brockwell.
Clifford Drift.					
Harperley	...	...	Crook	...	5 Qr., Main Coal, Fireclay Seam.
Harperley "Witton"			Witton-le-Wear		Marshall Green also ganister.
Hazard	...	...	Hetton-le-Hole	...	5 Qr., Main Coal, Maudlin, Low Main.
Hedley Hill	...	...	Tow Law	...	5 Qr., Main Coal, 3 Qr., Harvey, Ballarat.
Holmside Thomas	...	...	Chester-le-Street		5 Qr., Main Coal, Shield Row.
Houghton	...	...	Fence Houses	...	5 Qr., Main Coal, Maudlin, Low Main.
Hunwick	...	...	Willington	...	Harvey, Busty, Brockwell, 5 Qrs and Victoria.
Larch Hill	...	...	Wolsingham	...	
Lintz "Anna"	...	...	Lintz Green	...	Tilley, Main Coal, Hutton, Busty 3 Qr. and Brockwell.
Low Beechburn	...	...	Crook	...	Yard, Harvey, Hutton, Busty.
Marshall Green	...	...	Witton-le-Wear		Marshall Green also ganisterseam.
Malton Manor House			Durham	...	Brockwell and Busty.
New Brancepeth No. 2			Durham	...	Busty, Brockwell and Victoria.
" " 3			Durham	...	Hutton, Harvey and Busty.
Newfield	...	...	Willington	...	Harvey, 5 Qr., Beaumont, Brockwell.
Newbottle "Dorothea"			Fence Houses	...	5 Qr., Main Coal, Maudlin.
Newbottle "Margaret"			"	...	Main Coal, Brass Thill, Low Main, Hutton, Maudlin, Harvey and Busty.
Newton Cap A & B	...	...	Bishop Auckland		Brockwell, Harvey, Busty and Constantine.
Norwood	...	...	Gateshead	...	Stone Coal and Brockwell.
North Bitchburn	...	...	Crook	...	Harvey, Constantine, 5 Qr., Ballarat, Top Main, and Brockwell.
Ravensworth "Betty"			Lamesley	...	High Main, Maudlin, Yard, Low Main and 6 Qr.
Reddymoor	...	...	Crook	...	Yard, Ballarat.
Rough Lea	...	...	Willington	...	Top Main, 5 Qr., Ballarat, Constantine and Harvey.
Sacriston, Shield Row			Durham	...	Shield Row.
Seaham	...	...	Seaham	...	Maudlin, Main Coal, Low Main, Hutton.
South Brancepeth Busty			Willington	...	Busty and Yard.
South Garesfield	...	...	Lintz Green	...	Hutton, Townley, 3 Qr., Tilley, Busty, Brockwell and Victoria.
South Medomsley "Mary."			Dipton	...	Tilley, Busty, 3 Qr., and Brockwell.
South Medomsley "Drift."			Dipton	...	Main Coal, Shield Row, Low Hutton.
Stargate	...	...	Ryton	...	Townley, Stone Coal, 5 Qr., Tilley and 3 Qr.
Swalwell "Garesfield"			Swalwell	...	5 Qr., Brockwell and Tilley.
Tanfield Moor	...	...	Stanley	...	Brass Thill, Hutton and Main Coal.
Townley "Emma"	...	...	Ryton	...	Tilley, Stone Coal, 5 Qr., 3 Qr. and Brockwell.
Tudhoe	...	...	Spennymoor	...	Hutton, Busty, Brockwell.
Tursdale	...	...	Ferryhill	...	Busty and Brockwell.
Twizell	...	...	Chester-le-Street		Busty.
Ushaw Moor	...	...	Durham	...	Harvey, Busty and Brockwell.
Victoria "Garesfield"			Rowlands Gill	...	Stone Coal, Tilley, 5 Qr., 3 Qr. and Brockwell.
West Pelton	...	...	Chester-le-Street		Shield Row, 5 Qr., Low Main.
Willington	...	...	Willington	...	Jet, Ballarat, B. Hutton, Harvey and 3 Qr.
Witton-le-Wear	...	...	Witton-le-Wear		Ganister seam.

CHAPTER VII.

YORKSHIRE.

SHEFFIELD DISTRICT.

In the manufacture of silica-bricks the Sheffield district takes a prominent position. The local clays associated with the rocks used for silica-bricks also furnish good and abundant material for firebricks of various kinds.

The refractory fireclays occur in the lower part of the Lower Coal Measures in the following position, indicated by capitals:—

Silkstone Coal—	Ft.
Measures	1,230
Wharnccliffe Edge Rock	10 to 50
Shale	18
Halifax Hard Bed Band Coal	$\frac{2}{3}$
WHITE CAR FIRECLAY	3
Bind and stone bind	15
Loxley Edge Rock	60
Bind and Shale	0 to 120
Halifax Hard Mine (Ganister) Coal	0 to 2½
Ganister	6 in. to 5
FIRECLAY	0 to 5
Shale	4 ft. to 6
Clay (Middle Bed or Halifax Soft Band) Coal	3 in. to 1
FIRECLAY and bastard ganister	0 to 5
Middle Bed Rock	0 to 20
Shale	30 to 40
Coking or Soft Bed Coal	3 in. to 3
Shale	0 to 30
Crawshaw Sandstone	40 ft. to 70
Shale	60
Pot Clay Coal	1 in. to ¼
FIRECLAY (Pot Clay, Stannington, Black or Country Clay)	2 ft. to 5
Millstone Grit	—

The situation of the mines and works is given on p. 69, fig. 2.

The White Car Fireclay is at present worked in the Little Don Valley above Deep Car: the Pot Clay of the kind suitable for steel crucibles is obtained on the Ughill moorlands, west of Sheffield, but although the same bed crops out in the Loxley Don and Little Don valleys it is mined as a fireclay and was only found as a Pot Clay at outcrop. The bulk of the clay in the Don Valley comes from the fireclay below the Halifax Hard Mine Coal and below the Clay or Middle Bed Coal.

The coals and clays between the Millstone Grit and the Halifax Hard Bed Band Coal crop along the Little Don Valley west of Deep Car and are continuous with those outcrops in the Don Valley about Bullhouses west of Penistone, thus forming a connection of the Sheffield with the Huddersfield and Halifax districts.

MINES AND QUARRIES INDICATED BY NUMBERS ON THE MAP. (p. 69).

1, Woodend; 2, Little Matlock; 3, Broadhead; 4 & 5, High Matlock; 6, Griffs; 7, Brookside; 8, Storrs; 9, Storrs Bridge; 10, Hill Top; 11, Intake; 12, Wadsley; 13, Myers Lane; 14, Stubbin; 15, Loxley Common; 16, Worrall; 17, Hagg Stones; 18, Kirk Edge (disused); 19 & 20, Beely Wood; 21, Beely Wood Quarry; 22, Wharnccliffe Woodend; 23, Wharnccliffe Bearing; 24, Thornhurst; 25, Crossland's (Townend); 26, Wharnccliffe; 27, Armitage; 28, Clough; 29, Deepcar Fireclay; 30, Henholmes; 31, Bracken Moor; 32, Stocksbridge.

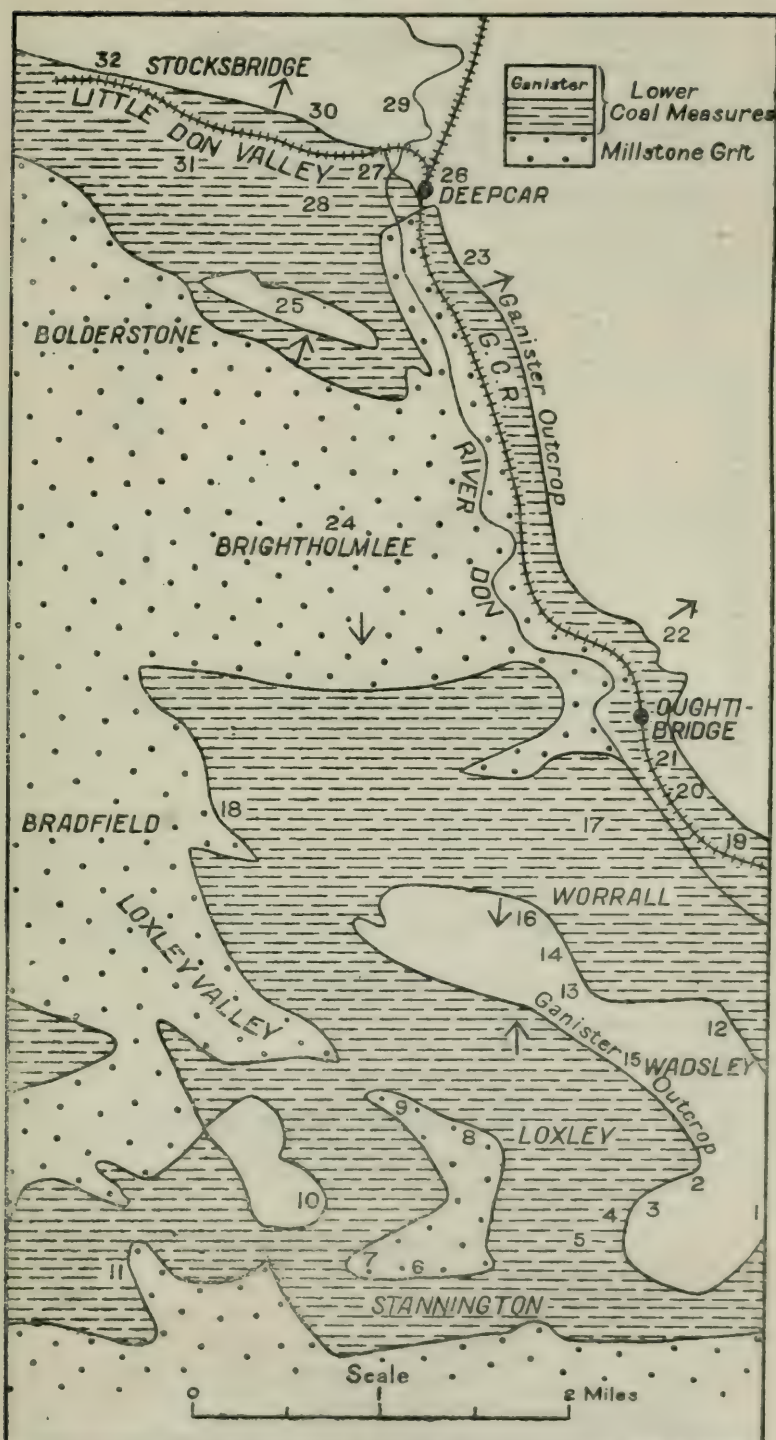
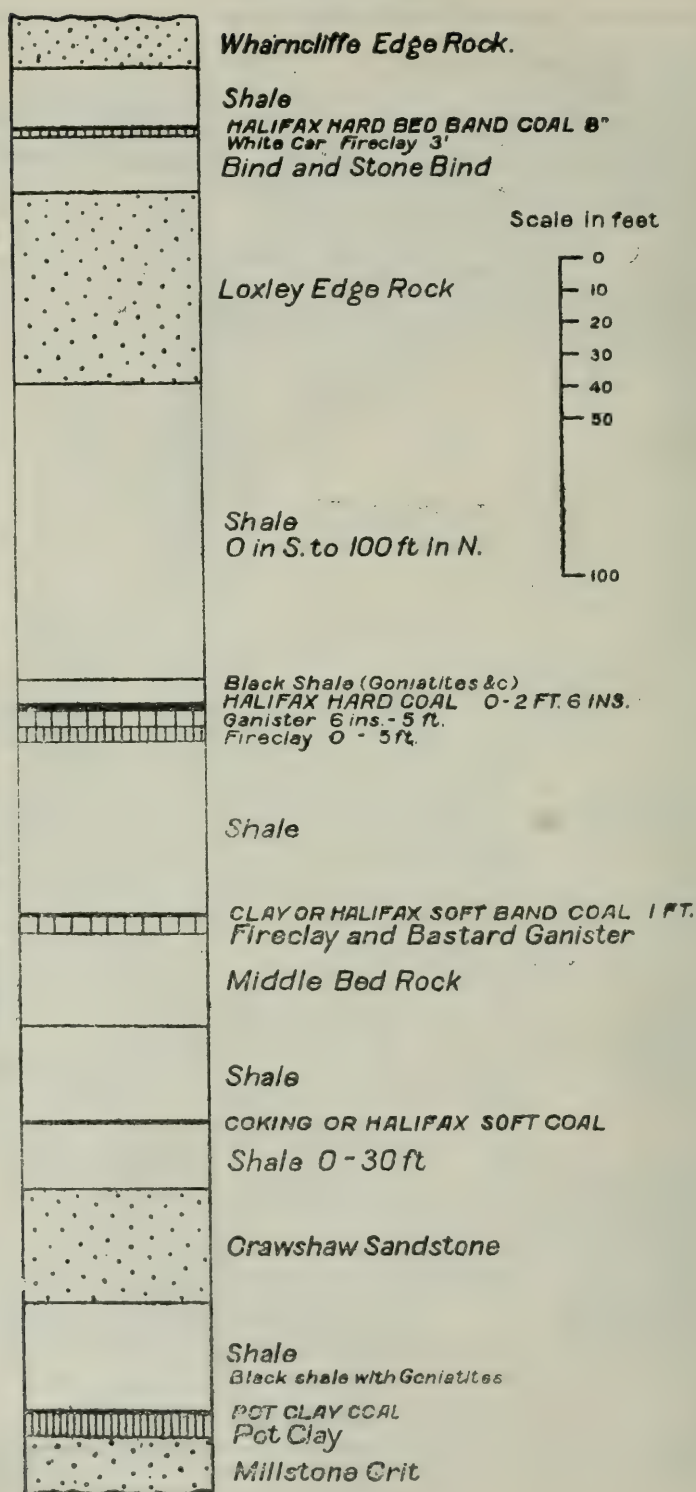


FIG 2.—Map of the Lower Coal Measures in the Sheffield district.

Fig. 3.—Section of the Lower Coal Measures in the Sheffield district.



Supplies of raw material are abundant. In the Don and Little Don valleys the mines and works are conveniently situated for transport by rail of raw materials and manufactured articles. Transport in the Loxley Valley is by road and is exceptionally heavy from the distant and exposed moorlands about Ughill. Since the Pot Clay only occurs in this remote district there may be said to be a shortage of material during wet or winter months when the mines have to be closed down or road transport is impossible. For this reason a good deal of crucible clay (commonly called Derby Clay by the Steel Makers) comes to the district from the south of Derby and Leicestershire.

J. & J. DYSON & Co.

Stannington.

Griffs and Wheatshire Mines.

Works and Mine: Situated one mile west of Knowle Top.

Maps: One-inch New. Ser. Ordnance and Geological 100; six-inch Yorkshire 294.

Latitude $53^{\circ} 23' 40''$. Longitude $1^{\circ} 33' 30''$.

Geological formation: Lower Coal Measures.

The bed lies directly on the Millstone Grit and is worked from a level at the Brick Works. It is followed along the strike east and west and to the south in the direction of rise.

Although this clay is on the same horizon as that worked at the company's mines at Wheatshire, it does not yield any Pot Clay but consists of a greyish sandy fireclay (termed Brick Clay) about 5 ft. thick. The roof is a black shale containing goniatites and *Pterinopecten* with a coal $\frac{1}{2}$ in. thick at the base. A dark grey sandy shale forms the floor of the Brick Clay and occasionally rises up into the clay forming a waste termed 'shoddy.'

Reserves are abundant.

Treatment: The level opens near the bins and the material is roughly hand-sorted before entering the mills. A considerable amount of clay comes by road from the Wheatshire Mines, which adjoin and work the same bed as at Platts Clay Mine.

Firebricks form the staple output; the best are made from a mixture of clay from Storrs Level with proportions from Wheatshire. In manufacturing nozzles and stoppers some burnt ganister from Wood End (p. 68) is added to the Pot Clay from Wheatshire.

J. DRABBLE & SONS,

Stannington.

Brookside Fireclay Mine.

Works and Mine: Situated opposite the Griffs Mine, on the north side of Storrs Brook.

Levels are opened on the same bed as at Griffs. Some firebricks are made on the spot, but the bulk of the raw material is carted into Sheffield.

B. TRICKETT & Co.

Stannington.

Intake Clay Mine.

Works and Mine: Situated one-quarter of a mile west of Load Brook.

Maps: One-inch New Ser. Ordnance and Geological 100; six-inch Yorkshire 293.

Latitude $53^{\circ} 23' 47''$. Longitude $1^{\circ} 35' 50''$.

Geological formation: Lower Coal Measures.

A series of levels on the eastern slopes of Rod Moor are on the outcrop of the same bed as at Platts.

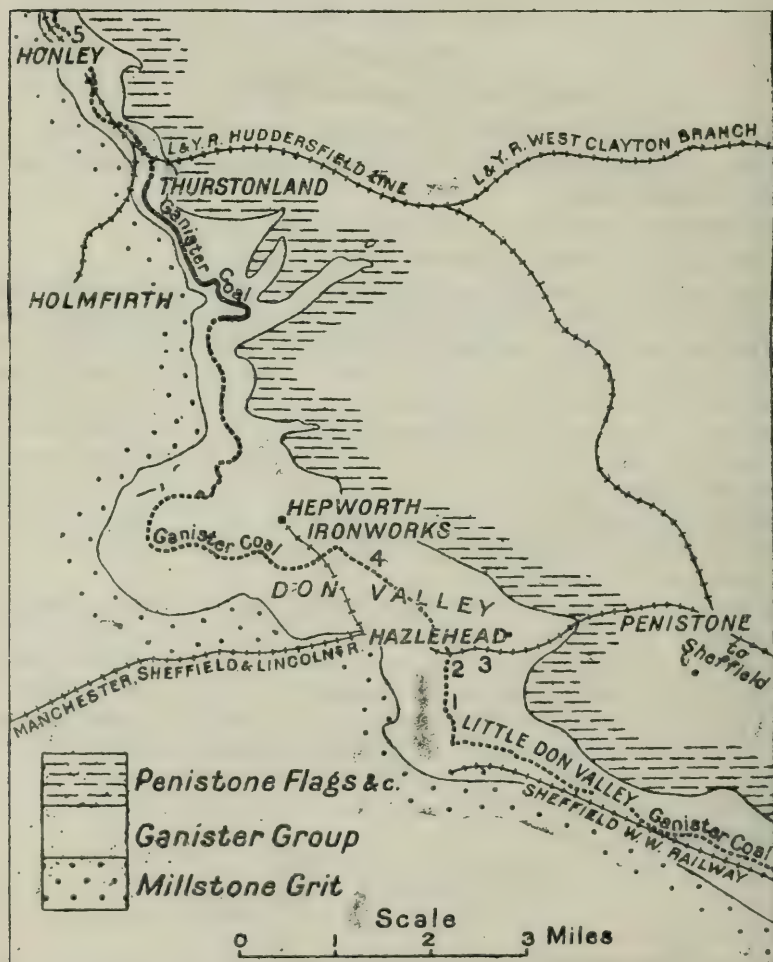


FIG. 4.—Map of the Lower Coal Measures in the Don Valley.

The mines and works are somewhat inaccessible, the roads having a high gradient and the position is exposed.

Reserves: Abundant.

HUGH DRABBLE & SONS.

Stannington.

Platt's Clay Mine.

Mine: Situated near Platt's Lane, one-quarter of a mile south-west of Ughill.

Maps: One-inch New Ser. Ordnance 99, Old Ser. Geological 81 N.E.; six-inch Yorkshire 287, 293.

Latitude $53^{\circ} 24' 5''$. Longitude $1^{\circ} 37' 4''$.

Geological formation: Lower Coal Measures.

There are no works at this mine and the whole of the material is sold as lump clay. The cartage from the mine is costly and its situation is exposed. The level is opened on the Pot Clay Coal and works the underclays to the rise.

An average section of the mine shows:--

									Ft. In.
Black shale with goniatites.	<i>Pierinopecten</i>	...	...	...	...	...	...	...	4 0
Coal	...	...	...	...	...	...	...	6 to 6	3
Dark shale	...	...	...	...	...	...	...	...	2 6
Best Crucible Clay	...	...	...	...	...	...	...	...	2 6
Grey clay	...	...	...	...	...	...	...	...	1 6

The dark shale and grey clays are sold as a Brick clay, but the most important product of the mine is the best crucible clay. This is a dark-grey, unctuous clay with numerous shining slip-faces resembling slickensides. It can be regarded as the type of Pot Clay known in the Sheffield district as 'Stannington,' 'Black' Clay or 'Country' Clay. At present the bed is free of deleterious materials and the mining conditions are favourable.

Reserves: Considerable.

T. WRAGG & SONS.

Loxley, near Sheffield.

Storrs Clay Mine.

Works and Mine: Situated in the Loxley Valley one-quarter of a mile east of Storrs Bridge.

Maps: One-inch New Ser. Ordnance and Geological 100, six-inch Yorkshire 294.

Latitude $53^{\circ} 24' 10''$. Longitude $1^{\circ} 33' 50''$.

Geological formation: Lower Coal Measures.

Levels on the same outcrop of clay as that mined at Griffs are situated close to the works. Clay is also obtained from Intake and Wheatshire.

The trade is chiefly the manufacture of special articles, nozzles, tuyeres, runners, used in the Sheffield district, and no silica bricks or firebricks are made.

Reserves: Considerable.

T. MARSHALL & Co.

Storrs Bridge, Sheffield.

Storrs Bridge Clay Mine.

The works and clay-levels of this Company lie in the Loxley Valley, about one-quarter of a mile west of Messrs. Wragg & Sons, and work identical outcrop beds.

GREGORY, REDDISH & Co.

Deepcar, near Sheffield.

Clough Fireclay Mine.

Works: At Deepcar.

Mine: Clough Mine, near the main road to Bolderstone, $\frac{1}{2}$ mile south-west of Deepcar.

Maps: One-inch New Ser. Ordnance 87, Old Ser. Geological 87 S.W.; six-inch Yorkshire 282.

Latitude $53^{\circ} 28' 40''$. Longitude $1^{\circ} 34' 30''$.

Geological formation: Lower Coal Measures.

The clay used in the manufacture of firebricks and other fireclay goods is obtained from a level opening close to the works. An average section of the mine shows:—Black shale roof, Coal 0 to 2 in., Fireclay 4 ft. to 4 ft. 9 in., gritty rock floor.

The clay is at its best near the outcrop and becomes sandier and harder when followed to the south in the direction of rise. Irregularities in the seam are caused by the incoming of grey sandy micaceous nodules and some ironstone nodules. There is also a lateral passage into a black clay, said to be pyritous in places and to contain traces of oil. The clay makes a good firebrick but is not suited for crucibles.

Reference to the silica-brick industry is given in 'Special Reports on the Mineral Resources,' vol. vi, Ganister, etc. (*Mem. Geol. Surv.*), Ed. 2, 1920, p. 25.

Reserves: Abundant.

THE ARMITAGE WORKS CO., LTD.

Deepcar, near Sheffield.

Deep Car Fireclay Mine.

Works and Mine: The level of this mine is situated one-quarter mile north of the Company's Brick Works at Deepcar.

Maps: One-inch New Ser. Ordnance 87, Old Ser. Geological 87 S.W.; six-inch Yorkshire 282 S.W.

Latitude $53^{\circ} 28' 53''$. Longitude $1^{\circ} 33' 45''$.

Geological formation: Lower Coal Measures.

The clay worked is the White Car Fireclay which forms the floor of the Halifax Hard Bed *Band* Coal (not to be confused with the Halifax Hard *Mine* Coal). This is the highest local clay used as a refractory in the Sheffield district.

Reserves: Abundant.

Mode of Working: The clays are mined along the strike and in the direction of dip which is toward the north.

Treatment: No special treatment.

Products: In normal times the clay is used extensively in the manufacture of sanitary pipes, enamelled wares, etc.

The Company also make firebrick from the clay below the Hard Mine Coal from levels in its outcrop between Deepcar and Henholmes. The firm makes ganister mixture but no silica-bricks.

Huddersfield, Halifax and Leeds District.

West of Stocksbridge the outcrop of the Lower Coal Measures is continued along the Little Don Valley to Langsett and thence northwards across the Don Valley past Hazlehead Bridge to Honley (map, p. 72). This long and broad outcrop contains large reserves of good fireclay below the Hard Mine Coal, and of ganister of an average thickness of 1 ft. 6 in., but varying much in quality. A bastard ganister or silica-rock occurs locally beneath the Hard Bed Band Coal and is quarried at Bullhouse. The quality of the Pot Clay resting on the Millstone Grit has not been tested by mining.

North of Honley the outcrop of the Lower Coal Measures extends to Huddersfield and thence northwards past Elland to Halifax and beyond (map, p. 76). The lower part of the sequence is again the source of the raw material, but around Leeds, the fireclay below the Better Bed Coal is used partly for firebricks and sanitary ware on the southern outskirts of the city. Firebricks are also made from the fireclay below the Halifax Hard Coal, near Shipley.

There is abundance of raw material.

Taking the Silkstone Coal as the summit of the Lower Coal Measures, the position of the Better Bed Coal and of the general sequence below it is given in the following table:—

<i>Silkstone (Blocking or Barcelona) Coal.</i>										Ft. In.	
Measures	...	...	...	...	...	...	...	...	...	360 to 430	0
Better Bed Coal	...	...	...	...	...	...	...	...	...	...	2 0
FIRECLAY											
Measures	...	...	...	...	...	...	...	...	...	10 to 80	0
Elland Flagstones	...	...	...	...	...	...	...	...	...	130 to 210	0
Measures	...	...	...	...	...	...	...	...	...	50 to 120	0
80 Yards Band Coal ¹ (Upper Band Coal)	...	...	...	...	...	...	...	...	...	0 to	6
80 Yards Band Rock	...	...	...	...	...	...	...	...	...	0 to 20	0
Measures	...	...	...	...	...	...	...	...	...	80 to 120	0
48 Yards Band Coal ¹ (Hard Bed Band Coal)	...	...	...	...	...	...	...	...	...	0 to 1	2
FIRECLAY (not worked)											
Measures (with 48 Yards Rock or Galliard)	...	...	...	...	...	...	...	...	...	...	35 0
40 or 36 Yards Band Coal ¹	...	...	...	...	...	...	...	...	...	7 in. to 1	8
FIRECLAY											
40 or 36 Yards Band Rock (Galliard)	...	...	...	...	...	...	...	...	...	0 to 15	0
Measures	...	...	...	...	...	...	...	...	...	90 to 100	0
Halifax Hard Bed Coal (Ganister Coal)	...	...	...	...	...	...	...	...	...	3 in. to 2	0
FIRECLAY											
Measures	...	...	...	...	...	...	...	...	...	...	30 0
Middle Band or Clay Coal	...	...	...	...	...	...	...	...	...	6 in. to	20
Measures with Middle Band Rock	...	...	...	...	...	...	...	...	...	35 to 60	0
Halifax Soft Bed Coal	...	...	...	...	...	...	...	...	...	...	1 6
Measures	...	...	...	...	...	...	...	...	...	...	80 0
Coal with underclay 5 ft. <i>Rough Rock</i>	...	...	...	...	...	...	...	...	...	0 to 0	6

¹ So named from a supposed average distance above the Halifax Hard Bed Coal.

The fireclays mostly in use are those below the Halifax Hard Bed Coal, 40 or 36 Yards Band Coal and 48 Yards Band Coal, the two last being extensively mined around Halifax. Siliceous rocks are furnished by the 40 or 36 Yards Band Rock, and to a less extent by the Ganister below the Halifax Hard Bed Coal. With the Better Bed Fireclay the 36 Yard Rock of Meanwood is used.

The manufacture of fireclay goods is conducted on an extensive scale around Leeds and Halifax, including all kinds of refractory bricks, blocks, coke-oven bricks, gas-retorts, acid-resisting goods, sanitary and glazed ware.

There is abundance of raw materials and most of the mines are conveniently situated near railways.

THE LEEDS FIRECLAY COMPANY, LTD.

Wortley, Leeds.

Branches.

Joseph Cliff & Sons.

W. Ingham & Sons.

Burmantofts Co.

Wortley Fireclay Co.

Edward Brooke & Sons.

Joseph Brooke & Sons.

Oates & Green, Ltd.

The Leeds Fireclay Company is the largest concern of its kind in Great Britain; it operates the following mines and quarries:—

THE LEEDS FIRECLAY COMPANY, LTD., WORTLEY, LEEDS.

Schedule of the Mines and Quarries.

Name.	Mine or quarry.	Situation (parish).	Maps.			Geographical position.		Depth in Fathoms.	Approximate gradient of seam.	Approximate height above sea level.	Seam worked.	Average section.	Manufactures.
			1 in. New Ser.	6 in.	Lat.	deg. min. sec.	Long.						
THE LEEDS GROUP. Harehills ...	Mine (shaft)	Potternewton	70	Yorkshire 203 S.E.	53 48 53	deg. min. sec.	1 29 50	255	1 in 12	210 Ft.	Better Red Coal and Fireclay	Roof: Shale. Seam: Coal, 1 ft. 2 in. to 3 ft. Fireclay, 2 ft. 6 in. to 3 ft. Floor: Fireclay and Ironstone	Refractory, Sanitary and Glazed Goods.
	Gipton No. 2 Mine (Day-hole)	Do.	70	203 S.E.	53 49 0	1 30 28	--	--	1 in 5	250	Beeston Coal and Underclay.	Roof: Shale Seam: Coal, 2 ft. 6 in. Under Clay, 1 ft. 6 in. Floor: Hard clay with ironstone nodules	Acid Resisting Goods for Chemical Manufacturers.
1 Elland Road	Quarry	Hunslet ...	78	218 S.W.	53 46 36	1 33 52	--	--	1 in 12	175	Bastard Fireclay	Grey Shale, 2 ft. Coal suit, 2 in. Bastard Clay, 2 ft. 6 in. to 2 ft. 9 in. Inferior clay below.	Sanitary Pipes and Glazed Goods.
Cardigan ...	Mine (shaft)	Beeston ...	78	217 S.E.	53 46 30	1 35 9	164 1/2	--	1 in 15	164	Better Red Coal and Fireclay.	Roof: Shale. Seam: Coal, 9 in. Fireclay, 2 ft. 6 in. to 3 ft.	Refractory, Sanitary and Glazed Goods.
Coronation	Mine (shaft)	Holbeck ...	78	217 S.E.	53 46 53	1 35 13	78	--	1 in 20	150	Do.	Floor: Fireclay with Ironstone.	

1 This quarry is now closed. The bed of clay lies about 30 ft. below the Beeston coal.

Name.	Mine or quarry.	Situation (parish).	Maps.		Geographical position,			Depth in Feet.	Approximate gradient of seam.	Approximate height above sea level.	Seam worked.	Average section.	Manufactures.
			1 in. New Ser.	6 in.	Lat.	deg. min. sec.	deg. min. sec.						
THE GREENSBLE ...	LEEDS GROUP— <i>cont.</i> Mine (Day-hole)	Fudsey ...	69	Yorks. 217 N.W.	53 47 20	53 48 23	1 39 57	—	1 in 20	Ft. 590	Better Bed Coal and Fireclay	Roof: Shale. Seam: Coal, 1 ft. 3 in. Fireclay, 2 ft. 4 in. to 2 ft. 6 in. Floor: Fireclay with Iron-stone	Refractory, Sanitary and Glazed Goods.
Stanningley	Quarry	Farsley ..	69	202 S.W.	53 48 23	1 39 57	—	—	—	390	Stanningley Rock	Baring 8 ft. to 10 ft. The rock is 40 ft. to 50 ft. thick —about 25 ft. being quarried	Refractory Goods.
THE HALIFAX GROUP. Beacon ..	Mine (Day-hole)	Northowram ..	77	231 N.W.	53 43 34	53 43 34	1 50 50	—	1 in 24	650	36 Band Coal and Fireclay Do.	Roof: Blue Shale. Seam: Coal, 7 in. to 9 in. Fireclay, 3 ft. 9 in. to 4 ft. 9 in. Floor: Band Stone.	Refractory, Sanitary and Glazed Goods.
Ellen Royd	Mine (Day-hole)	Do.	77	231 N.W.	53 43 48	1 51 23	—	—	1 in 25	600	Do.		
Shubbenhall	Mine (shaft)	Southowram ..	77	231 N.W.	53 43 29	1 49 35	147	147	1 in 24	400	Do.		
NEW PEACE	Mine (shaft)	ELLID. Dighton ...	77	246 S.E.	53 39 53	1 45 15	186	186	1 in 24	186	Halifax Hard Bed Coal and Clay	Roof: Blue Shale. Seam: Coal, 2 ft. 4 in. Gaultier, 8 in. Fireclay, 6 ft. thick, but the lower 3 ft. is inferior and is not worked	—

JOSEPH MORTON & Co.

Siddal, Halifax.

Cinder Hill Fire Clay Mine.

Works and Mine: Siddal, Halifax. There are also Brick Works at Siddal, Mytholme, Howcans (Holmfild).

Maps: One-inch New Ser. Ordnance 77, Old Ser. Geological 88 N.E.; six-inch Yorkshire 231.

Latitude $53^{\circ} 42' 35''$. Longitude $1^{\circ} 50' 30''$.

Geological formation: Lower Coal Measures.

The fireclays made use of are those below the Halifax Hard Bed Coal and the 36 Yards Band Coal, which are mined along their outcrop. Very little use is made of the ganister below the Halifax Hard Coal, and it is left as a roof to the underlying clay in those places where the coal has been worked.

Reserves: Abundant.

THE WROSE HILL FIRECLAY CO., LTD.

Carr Lane, Shipley, Yorks.

Situation: At Wrose Hill.

Maps: One-inch New Ser. Ordnance 69, Old Ser. Geological 92 S.E.; six-inch Yorkshire 201 S.E.

Latitude $53^{\circ} 49' 55''$. Longitude $1^{\circ} 45' 20''$.

Geological formation: Lower Coal Measures.

The Halifax Hard Bed Clay, here 5 ft. 6 in. thick, is mined at Wrose Hill. The reserves are about 20 acres. Firebricks and blocks for steel works are made.

D. SHARRATT & SONS, LTD.

Storth Firebrick and Sanitary Pipe Works, Elland.

Mines and Quarries: Storth No. 1 and No. 2 and Ainley Grange, about 1 mile S.E. of Elland.

Maps: One-inch New Ser. Ordnance 77, Old Ser. Geological 88 N.E.; six-inch Yorkshire 246 N.W.

Latitude $53^{\circ} 40' 35''$. Longitude $1^{\circ} 49' 15''$.

Geological formation: Lower Coal Measures.

The clays worked are the Halifax Hard Bed or 'White Clay,' average thickness 5 ft. 6 in., and the 36 Yard Band or 'Blue Clay,' average thickness 7 ft. Both clays are employed in making firebricks. The reserves of clay are large.

FARNLEY IRON CO., LTD.

Farnley, Leeds.

Mine: White's Mine, Farnley.

Maps: One-inch New Ser. Ordnance 77, Old Ser. Geological 88 N.E.; six-inch Yorkshire 217 N.E.

Latitude $53^{\circ} 46' 55''$. Longitude $1^{\circ} 36' 45''$.

Geological formation: Lower Coal Measures.

The fireclay used is the seat earth of the Better Bed Coal, here a little over 2 ft. thick; hard and soft portions of the bed are selected for different purposes. Firebricks and furnace blocks are made but the principal manufactures are sanitary, salt-glazed and enamelled bricks, for which special mixtures are made.

S. WILKINSON & SON.

Elland, Halifax.

Blackley Pit and Woodman Mine.

Situation: About one mile south of Elland.

Maps: One-inch New Ser. Ordnance 77, Old Ser. Geological 88 N.E.; six-inch Yorkshire 246 N.W.

Geological formation: Lower Coal Measures.

The beds worked are the 36 Yards Band Coal and Clay, the Halifax Hard Bed Coal and Clay, and the Soft Bed Coal. The 36 Yards Band fireclay is 6 ft. thick; the Hard Bed fireclay is 4 ft. 6 in. thick. The reserves are ample. Firebricks, coke-oven bricks, etc., are made.

Ingleton Coalfield.

In this area no fireclays are worked for firebrick. At the only coal-pit in operation, that of the New Ingleton Colliery, a 21 ft. bed of white fireclay of unknown quality, but with balls of ironstone, occurs at a depth of 170 yards (base of clay) in No. 2 downcast shaft. None of the other clays appear to be of value.

Years ago, a fireclay—presumably a pot-clay—used to be worked at one of the old pits of the Ingleton Colliery Co.

The Four Foot, or Main Coal, is underlain by a 2 ft. bed of fireclay at the Old Newfield Pit, a little south of the New Ingleton Colliery, but it is of little value. The 'Segar' clays mentioned in the section sunk through in the Newfield Pits ('The Geology of the Country around Ingleborough,' Explanation of Quarter Sheet, Old Ser. 97 S.W., New Ser., Sheet 50, 1890, p. 81) are probably pot-clays.

At a lower horizon a 4 ft. bed of pale grey to brownish pot clay, associated with a 2 in. to 4 in. coal, plotted on the one-inch Geological map, Old Ser. 91 N.W., is worked at potteries (e.g., Wm. Bateson & Sons, and T. Coates) situated at Burton-in-Lonsdale, about 3 miles W.S.W. of Ingleton (Old Ser. 98 S.E., New Ser. 49), where the coal is 'slack' and the clay varies from 3 ft. 6 in. to 5 ft. in thickness.

This clay is unsuitable for firebrick, being too close in texture, and containing 'bullets' of stone and ironstone; nor will it do for saggars. It is chiefly made up into stone jars with stoppers, and flowerpots.

At a lower level a clay cropping out on ground adjoining Clifford Hall, a little S.W. of Burton Hall, might make a second-class firebrick. It is a pale grey to brownish clay with few or no plant remains and occasional 'bullets.'

Yorkshire.

List of Mines working or having worked Fireclay.

NAME OF MINE.	SITUATION.	BEDS WORKED.
Ainley Green (?Grange)	Elland ...	Halifax Hard and 36 Yard Band.
Ambler Thorn ...	Halifax ...	Halifax Hard.
Ashfield ...	Farnley ...	Better Bed.
Ashgrove ...	Southowram ...	
Band Bed Drift ...	Hazlehead ...	Halifax Hard.
Bank Royd ...	Denby Dale ...	Whinmoor.
Beacon ...	Halifax ...	36 Yard Band.
Birks Fireclay ...	Thornton ...	
Blackley ...	Elland ...	36 Yard Band and Halifax Hard.
Bracken Moor ...	Deepcar ...	
Bromley Fireclay ...	Denby Dale ...	Whinmoor.
Brookside ...	Stannington ...	
Bullhouse ...	Penistone ...	Halifax Hard.
Calder ...	Elland ...	
Caledonian ...	Worrall ...	(Standing).
Cardigan & Royds ...	Gelderd Road, Leeds	Better Bed.
Cinder Hill and Quarry	Halifax ...	36 Yards Band and Halifax Hard Bed.
Clough ...	Deepcar ...	Halifax Hard Bed.
Crabtree Hall ...	Halifax ...	
Crawshaw Clay ...	Ughill, Bradfield	
Deepcar Fireclay ...	Deepcar ...	Halifax Hard Bed Band.
Ellen Royd ...	Halifax ...	36 Yard Band.
Fieldhouse, New Place	Huddersfield	Halifax Hard.
Gildersome ...	Gildersome ...	Upper and Lower Brown Metal.
Great Miers and Siddal	Halifax ...	Halifax Hard Bed.
Greengates ...	Bradford ...	Halifax Hard.
Green Top ...	Pudsey ...	Better Bed.
Greystones ...	Sheffield ...	Halifax Soft Bed.
Griffs ...	Stannington	Pot Clay (Brick Clay)
Griffs Top Yard	Stannington	" "
Holmfield ...	Halifax ...	36 Yards Band.
Horley Green ...	Halifax ...	(Standing).
Ingleton (Grove)	Ingleton ...	Yard Seam (Abandoned Oct, 1914).
Intake ...	—	Pot Clay.
Langhouse ...	Worrall ...	Standing.
Little Matlock ...	Stannington	Halifax Hard.
Low Close ...	Holbeck ...	Better Bed.
Middleton Broom No. 1	Leeds ...	Crow Coal, Black Bed. Better Bed.
Mill Hill ...	Burton-in-Lonsdale	Abandoned.
New Hall ...	Elland ...	
Newmarket Spencer ...	Rothwell ...	Haigh Moor Seam.
Newmarket Swithens ...	Rothwell ...	Haigh Moor.
New Mytholme ...	Hipperholme ...	36 Yards Band.
Platts ...	Ughill, Bradfield	Pot Clay.
Pot Clay ...	Deepcar ...	(Standing).
Pot House ...	Stocksbridge ...	Halifax Hard.
Ravels ...	Leeds ...	Better Bed.
Royd Edge ...	Meltham ...	
St. Helens ...	Kirkburton ...	Black Bed.
Shibden Hall ...	Southowram ...	36 Yards Band.
Shipley ...	Shipley ...	Halifax Hard Bed.
Silica ...	Oughtibridge ...	Halifax Hard.
Sledbrook ...	Hazlehead ...	Halifax Hard.
Stocksbridge No. 1	Stocksbridge, Halifax.	Halifax Soft.
" " 3 ...	—	Halifax Hard, Ganister.
Storrs ...	Storrs, Sheffield	Pot Clay.

NAME OF MINE.	SITUATION.	BEDS WORKED.
Storrs Bridge ...	Loxley ...	Pot Clay.
Storth ...	Elland ...	Halifax Hard Bed.
Stubbin ...	Worrall ...	Halifax Hard.
Sunny Vale ...	Southowram ...	36 Yards Band.
Victoria... ..	Elland ...	Halifax Hard.
Wadsley Common	Wadsley, Sheffield	Halifax Hard.
Wadsley Park ...	Sheffield ...	Halifax Hard.
Waterclough ...	Southowram, Halifax.	Halifax Hard, Halifax Soft, 36 Yards Band.
Wharncliffe ...	Deepcar ...	Halifax Hard.
Wheatshire ...	Bradfield...	
White's ...	Farnley ...	Black Bed, Better Bed.
Woodend No. 1	Stannington ...	Halifax Hard.
Woodman ...	Elland ...	36 Yard Band and Halifax Hard.
Wrose Hill ...	Shipley ...	Halifax Hard Bed.

CHAPTER VIII.

DERBYSHIRE, LEICESTERSHIRE AND
WARWICKSHIRE.

EAST DERBYSHIRE.

Very little refractory firebrick is made in East Derbyshire. Some firebrick is made from the fireclay underlying the Deep Hard Coal, and probably from one or two other fireclays in the Middle Coal Measures; but none of these bricks are used for blast-furnaces or for any purposes for which a highly refractory material is required.

Nor are local fireclays in general use for other refractory purposes connected with the production of iron and steel. But the underclay of the Deep Hard Coal is used in at least one instance for 'botting' blast-furnaces and for setting firebrick.

The term Derbyshire Clay is applied in Yorkshire to refractory clay obtained from the South Derbyshire and Leicestershire Coalfield, mainly within Derbyshire, but also in the adjacent part of Leicestershire. This clay is described in a separate section, and belongs to a group of fireclays at the top of the Middle Coal Measures. It is significant that a similar group containing fireclays occurs at the top of the Middle Coal Measures in North Staffordshire (Blackband Group, with associated carbonaceous ironstones, there included with the Upper Coal Measures in the Geol. Surv. Mem.) and in Flintshire (Buckley Fireclay Group); and further, that beds of like nature are found in the same stratigraphical position in East Derbyshire, east of the Erewash Valley and of the Portland Pits. In East Derbyshire, however, these clays are not worked and their value as refractories appears not to have been tested.

MESSRS. J. OAKES & Co.

Pyebridge.

Riddings Ironworks, Brickworks and Colliery.

Situation: At Riddings, near Pyebridge Station.

Maps: One-inch New Ser. Ordnance and Geological 125; six-inch Derbyshire 40 N.E.

Latitude $53^{\circ} 4' 5''$. Longitude $1^{\circ} 20' 50''$.

Geological formation: Middle Coal Measures.

The fireclay used is the underclay of the Deep Hard Coal. In section it is as follows:—

	Ft.
Deep Hard Coal	2
Fireclay, without iron balls	2
„ more or less shaly, with iron balls	2

Reserves are evidently abundant.

Mode of working: The fireclay is mined with the overlying coal at the Company's collieries.

Treatment: The whole thickness of this fireclay is used after taking out the iron balls. The clay is left to weather for a year or more in a heap containing some 5,000 tons. The whole supply is obtained from the Company's coal-pits.

A siliceous firebrick is made from this fireclay with addition of some silica-rock and sand. The firebrick is supplied for coke-ovens, boiler-settings and cement-kilns, but has not yet been tried for furnaces. It is used also by Messrs. Oakes for their brick- and pipe-kilns.

The bricks are regarded as suitable for any purpose that does not require a heat above 1250° C., and are said to stand chemical action well. They are said not to expand at all, but to contract slightly above 1100° C. Messrs. Oakes use the fireclay for "botting" their blast-furnaces.

THE CLAYCROSS CO., LTD.

Claycross.

Situation: North of Clay Cross and south of Clay Cross Station—near the railway.

Maps: One-inch New Ser. Ordnance and Geological 112; six-inch Derbyshire 30.

Latitude $53^{\circ} 10' 44''$. Longitude $1^{\circ} 23' 30''$.

Geological formation: Middle Coal Measures.

From the clay worked near to Clay Cross Station the firm make only common bricks, but they also use there a fireclay from their colliery at Clay Cross, and from this fireclay they make firebrick for boiler settings and domestic firebacks. These bricks are evidently only low-temperature bricks.

Reserves: The reserves of fireclay are presumably large.

South Derbyshire and Borders of Leicestershire.

An important group of fireclays worked on the west side of the South Derbyshire and Leicestershire Coalfield, occurs in the highest strata of that Coalfield at a distance of 300 or 350 ft. below the top of the ascertained sequence of Coal Measures. These highest beds, assigned to the Middle Coal Measures, appear to be present only in the neighbourhood of Swadlincote, Church Gresley, Woodville and Moira, where they have been preserved in a shallow irregular and faulted synclinal basin, their area being defined approximately by the outcrop of the Ell Coal. The tract in which the refractory clay is worked lies mainly within Derbyshire, but partly in Leicestershire. (See sketch map Fig. 6.)

The fireclay group consists of several beds of fireclay found in association with and chiefly above the assemblage of minor coal-seams that come in far above the principal seams of the coalfield. Several of these fireclays are worked extensively for making sanitary-ware, etc.; but only one seam is in general use as a refractory clay for the production of high-class firebrick and

steel crucibles. This seam, the 'Fireclay Seam' or 'Main Fireclay,' known as 'Derby Clay,' and worked by five companies in the neighbourhood, provides a very large output of firebrick, besides being one of the few sources of crucible-clay in the country.

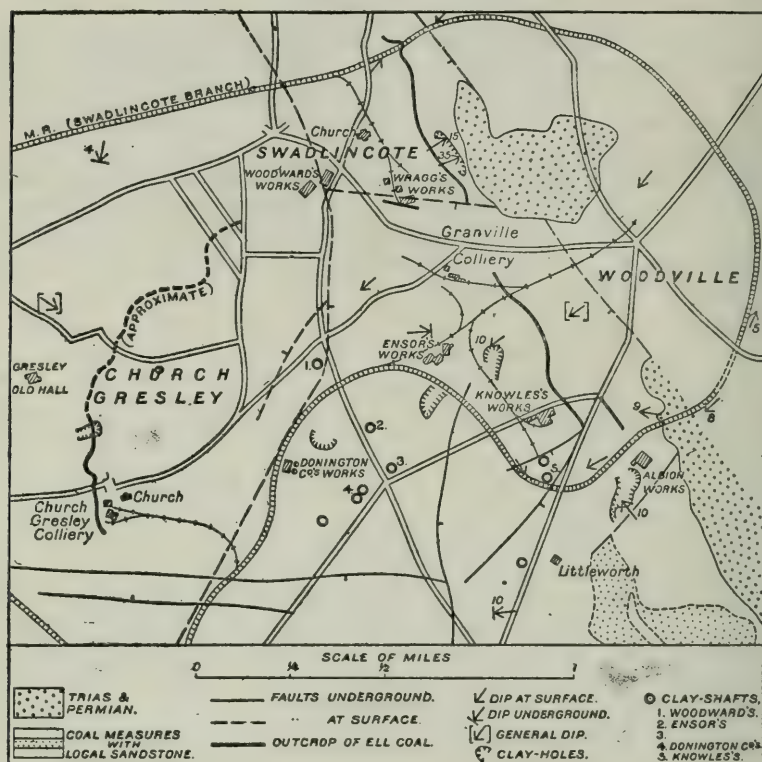


Fig. 6. Map of the Leicestershire—Derbyshire Clay area.

Certain beds can be recognised throughout the area in which the fireclay is worked. The Ell Coal is generally succeeded at a distance of a few feet by a seam known locally as the 'Fireclay' or 'Rider' Coal—the principal Rider Coal of this coalfield is at a much lower horizon. Above the Ell Coal and the local Rider, where present, a small but variable thickness of beds, for the most part shaly and of no economic value, is succeeded by a fireclay known throughout as the 'Bottle Clay'; and this in turn by the Main Fireclay, usually separated from the Bottle Clay by a thin coal. The Main Fireclay is overlain by a few feet of "marl" and "clunch" which may be surmounted by another thin coal.

The marl and clunch above the Main Fireclay and the Bottle Clay below it are worked for making sanitary-ware, etc., as is sometimes a clay between the Rider and Ell Coals. Two other coal-seams may be present close below the Ell Coal, and beneath these another clunch is worked locally.

The Main Fireclay, a tough saponaceous clay, without appearance of stratification, is of a grey colour, the upper part being generally lighter than the rest, and its more saponaceous character distinguishes it from neighbouring clays. It maintains its general characteristics throughout the neighbourhood of Swadlincote, Church Gresley, and Woodville, but varies in thickness between limits of 3 ft. 6 in. and 12 ft., with a usual thickness of 5-8 ft. It is mined at depths ranging from 50 ft. to 330 ft., and is also worked to a less extent by opencast. It is said to be in better condition when mined, though the clay worked by opencast under a cover of 30 ft. or 40 ft. may be practically as good as that mined at shallow depths.

The higher measures containing the Main Fireclay and associated clays are believed to extend southward over the whole of the Moira district nearly as far as Donisthorpe¹ (one-inch map 155 N.S.), with a thickness of about 350 ft. or more at Moira², so that the maximum depth of the Main Fireclay is approximately determined.

This clay has been worked very extensively at its outcrop in the northern part of the area, and is mined southward beyond Littleworth (*see* sketch map). But no evidence was obtained as to whether it maintains its character throughout the southern part of the area in the neighbourhood of Moira.

It seems that in the northern and central parts of the basin a large amount of the refractory clay remains unworked, at depths readily accessible to mining operations; and that these operations can be extended much further southward if the Main Fireclay retains its quality and thickness in that direction.

The firebrick of this district is supplied extensively as a furnace-brick for steel-, iron- and copper-works, particularly to the large armament firms and also to Government. Sheffield appears to be its principal market, but it is sent also to Leeds, Manchester, Newcastle, Glasgow, Birmingham, Llanelli and London. Some is made to the order of allied governments for the manufacture of explosives.

Sheffield is the chief market for the crucible-clay, some of which is sent also to Manchester.

The district has good railway communication. The loopline, known as the Swadlincote Branch of the Leicester and Burton Line (M.R.) encircles the northern and central area, in which the clay is now worked, and was evidently designed as a mineral railway to serve the coal- and clay-mining district. From it numerous small mineral lines branch to the several clay-works and collieries.

The Leicester and Burton Line and the Ashby and Nuneaton Joint Railway (M.R. and L. and N.W.R.) both serve the southern part of the area.

¹ C. Fox-Strangways. *Geology of the Leicestershire and South Derbyshire Coalfield* (*Mem. Geol. Surv.*), 1907, p. 52.

² *Op. cit.*, p. 53.

THOMAS WRAGG & SONS, LTD.

Swadlincote.

Situation: Swadlincote, near, and on the south side of the church. The opencast workings and mines are close to the works.

Maps: One-inch New Ser. Ordnance and Geological 141; six-inch Derbyshire 60 N.E.

Latitude $52^{\circ} 46' 25''$. Longitude $1^{\circ} 32' 50''$ (Clayhole).

Geological formation: Middle Coal Measures (highest beds).

The same seam of fireclay is worked for refractory material as at the other firebrick-works in the neighbourhood, the general sequence of Messrs. Wragg's measures being:—

	Ft.
CLUNCH	2
MARL	4
FIRECLAY (MAIN SEAM)	6-8
Coal	1
"BOTTLE CLAY"	6
"Rattle Jack" (shale)	3
Hard clunch	3
Binds	12
Rider Coal	4
CLAY ("DEEP FIRECLAY")	3-4
Ell Coal... ..	4
Dirt	more than 3
Coal }	6
Clay }	
Coal }	
CLUNCH	15

This section as given by Mr. Robert Wragg differs in detail from that recorded in the Survey Memoir¹, noticeably in the omission of two little coal-seams below the "Bottle-clay."

The Main Seam of fireclay is uniform in character throughout its thickness, except that the upper part is somewhat lighter in colour.

Messrs. Wragg work by opencast, besides the Main Fireclay, the two-foot clunch and the four-foot marl above that fireclay. The Bottle clay (so called because it once was, and perhaps still is used in the district for the manufacture of stoneware bottles) and apparently also the 15-foot clunch below the group of coals are employed for making sanitary pipes.

A considerable number of years ago Messrs. Wragg acquired also the neighbouring works known as Woodward's, which adjoin their own on the south and were opened in 1790.

Reserves of Main Seam: Available for a fair number of years.

Mode of working: The Main Seam is chiefly mined by adits, and is regarded as of better quality when mined; but it is also worked by opencast, under cover amounting to a maximum of 45 ft., and consisting chiefly of shale, with a thin coal-smut at the top and a band of sandstone a little lower. In the mines the cover averages from 50 to 70 ft.

The method of mining the "Main Seam" is to drive adits in the lower parts of its thickness and to extract that part first.

¹ Geology of the Leicestershire and South Derbyshire Coalfield (*Mem. Geol. Surv.*), 1907, p. 260.

The mine is then left for one or two years, so that the weak roof of fireclay may come down and completely fill up the adits and galleries. Afterwards the same adits and galleries are re-opened and the upper part of the seam is got out.

Treatment: For crucible-clay the "Main Seam" fireclay is ground fine and put up in bags dry.

For "best firebrick" the same fireclay is ground coarser with the addition of about 10 per cent. either of ganister-sand from Messrs. Wragg's sandpit at Parsley Hay (High Peak)—the sand itself being ground to crush the few quartzite pebbles in it—or of burnt and crushed firebrick. The choice between these two accessory materials seems to depend upon requirements. The fireclay, ground dry, is then "pugged." Firebricks are made by hand.

THE DONINGTON SANITARY PIPE & FIREBRICK CO., LTD.

Moira, Leicestershire
and
Church Gresley, Derbyshire.

Situation: Firebrick works, east of Church Gresley, and nearly a mile south by west from Swadlincote Church.

Maps: One-inch New Ser. Ordnance and Geological 141; six-inch Derbyshire 60 N.E.

Latitude $52^{\circ} 45' 35''$. Longitude $1^{\circ} 33' 0''$. Two shafts close together.

Geological formation: Middle Coal Measures (highest beds).

The Main Fireclay is the principal material used as a refractory.

The Main Fireclay varies in thickness here from 3 ft. to 6 ft. 6 in. It is said to be "fattest" or most saponaceous where thickest, and to deteriorate somewhat into a "leaner" and more sandy clay where thinnest.

Reserves are fairly large.

Mode of working: It is all mined by shaft at a depth of about 90 ft., the cover consisting chiefly of shales.

Treatment: For some special purposes the fireclay is allowed to weather, but for making firebrick and for crucible-clay it is used unweathered. When more clay is raised than is required at the time it is stacked at the pit.

ENSOR & CO., LTD.

Pool Works, Woodville, near Burton-on-Trent.

Situation: West of Woodville, about two-thirds of a mile S S.E. of Swadlincote Church.

Maps: One-inch New Ser. Ordnance and Geological 141; six-inch Derbyshire 60 N.E.

Latitude $52^{\circ} 45' 45''$. Longitude $1^{\circ} 33' 0''$.
Latitude $52^{\circ} 45' 40''$. Longitude $1^{\circ} 32' 55''$. { Two clay shafts south of the works.

Geological formation: Middle Coal Measures (highest beds).

The dip in Messrs. Ensor's mines is due south at a small angle, and a fault intervenes between their ground and Messrs.

Knowles's. The Main Fireclay is the only clay used for refractory purposes. At Messrs. Ensor's opencast and mines the general sequence of measures associated with the Main Fireclay is as follows:—

	Ft.	In.
Yellow clay and soil	5	0
Blue bind	7	0
Marl	4	0
Light clay... ..	4	0
Stone measures	9	0
Bind and ironstone	18	0
Cank-stone	1	6
Blue bind	10	0
Coal	1	6
Marl	2	6
FIRECLAY (MAIN SEAM)... ..	4	6
Coal		9
BOTTLE CLAY	5	0
Dark clunch	3	0
Blue clunch	4	0

The Main Fireclay ("Derby Clay") is grey in colour, fine-grained and saponaceous in texture, and uniform in character.

Reserves: Reserves of Main Fireclay are sufficient for many years to come.

Mode of working: Messrs. Ensor mine all their Main Fireclay, under thick cover by adits from the surface. There is no treatment of the raw material at the pit.

The associated clays used for purposes other than refractory are worked by opencast in a large claypit, in which the Main Fireclay is exposed. Where these clays are worked at present the cover is comparatively thin but it soon becomes too thick for opencast working.

JOHN KNOWLES & Co. (WOODEN BOX), LTD.

Wooden Box, Mount Pleasant Works, near Burton-on-Trent.

Situation: Works and Shafts:—Nearly half-a-mile S.W. of Woodville.

Maps: One-inch New Ser. Ordnance and Geological 141; six-inch Derbyshire 60.

Latitude 52° 45' 40". Longitude 1° 32' 20".

Geological formation: Middle Coal Measures (highest beds).

The Main Fireclay, which alone is used as a refractory clay, is mined at depths ranging generally from 180 to 300 ft. by shafts situated on the south side of the works, the deepest shaft descending to 332 ft. Messrs. Knowles regard the fireclay as more valuable when mined at such depths than when got comparatively near the surface. The thickness of the fireclay ranges up to about 7 ft. in the shafts, but is said to be 8 ft. or 9 ft. at the outcrop. The clay is uniform in character.

The following extract from the section of one of Messrs. Knowles's clay-shafts¹, north of Littleworth and just north of

¹ C. Fox-Strangways, "Geology of the Leicestershire and South Derbyshire Coalfield." (*Mem. Geol. Surv.*), 1907, p. 257.

oval shape, and in places 2 ft. thick. The bullions are easily taken out whole and leave the fireclay free from iron-shot grains. Apart from the bullions and the difference of colour between the upper and lower parts, the fireclay is regarded as uniform in character. The whole thickness of the clay is used, after taking out the bullions.

Only the Main Fireclay is worked as a refractory material, but associated clays (the clunches and the Bottle clay) are used for making sanitary ware, etc.

The Main Fireclay is ground for steel crucibles and for setting firebrick in gas-retorts.

For crucible-clay the Main Fireclay is ground fine in the dry state without any addition.

For firebrick the same fireclay is ground dry with addition of about 25 per cent. of burnt firebrick. The Albion Company have not tried an admixture of silica-sand.

Reserves are stated to be abundant and sufficient for many years to come. The fireclay is believed to extend eastward of the present workings under an available area of some thousands of acres.

Mode of working: The Main Fireclay and all the clays used are both worked by opencast ("quarry") and mined. The Main Fireclay, if not the other clays, appears principally to be mined. but when obtained from the deepest part of the quarry, under about 34 ft. of cover, it is regarded as practically equal in quality to the mined clay.

Warwickshire Coalfield.

GEORGE SKEY & Co., LTD.

Wilnecote Works, near Tamworth.

Situation: Close to Wilnecote Station.

Maps: One-inch New Ser. Ordnance and Geological 154; six-inch Warwickshire 5 N.E.

Geological formation: Coal Measures (lowest beds).

Two seams of clay are in regular use at Messrs. Skey's works, the "White Pottery Clay" between the Seven Foot and Bench Coals, and the "Fireclay" some distance below the Bench Coal. For some purposes the shaly clay overlying the fireclay is also used. These clays are mined by shaft.

The general sequence of the clays and associated measures in the Beauchamp Shaft of Messrs. Skey's Wilnecote Colliery is:—

	Ft.	In.
<i>Seven foot coal</i>	—	—
Measures	18	0
WHITE POTTERY CLAY, a pale grey fireclay	3-6	0
Measures somewhere about	18	0
<i>Bench coal</i>	—	—
Measures, with shaly clay at base, somewhere about	120	0
FIRECLAY, dark grey	?	?

[See Geol. Surv. Vert. Sect. of Warwickshire Coalfield, Sheet 21, Sect. No. 2 (Wilnecote Colliery): the thickness of the measures below the bench coal is here merely estimated from depths given for the White Pottery Clay (30 yards) and the fireclay (80 yards) in the Beauchamp shaft.]

The Coal Measures of the district exhibit, according to Messrs. Skey's statement, an anticlinal structure culminating in the neighbourhood of the Beauchamp Shaft and bringing up the clays they work comparatively near the surface, whereas these clays lie at a prohibitive depth for profitable mining in other parts of the coalfield.

Messrs. Skey make all kinds of stoneware for chemical work, but no firebrick. Complete vitrification of the clay mixtures is obtained at temperatures of about 1300° C.

THE HAUNCHWOOD BRICK & TILE CO., LTD.

Stockingford, Nuneaton.

Griff No. 3 Quarry, Chilvers Coton, Nuneaton.

Situation: About a mile south-west of Nuneaton.

Maps: One-inch New Ser. Ordnance 169; Old Ser. Geological 63 S.W.; six-inch Warwickshire 11 S.W.

Latitude 52° 31' 30". Longitude 1° 28' 35".

Geological formation: Middle Coal Measures.

The section of the strata worked is as follows:—

	Ft.	In.
Mixed clay below the Slate Coal	...	...
FIRECLAY, very good	8	0
Lady Coal	2	6
FIRECLAY, good	5	0
Coal	1	0
FIRECLAY, good	30	0
[Seven-foot] Coal...	...	...
FIRECLAY, good (for firebricks)...	2	0
Coal	...	...
Fireclay	...	3
Coal	...	...
FIRECLAY, good	4	6
Bind and ironstone balls	12	0
Fireclay bind	4	0
Coal	4	0
Dark fireclay (binds)	20	0
Coal	3	6
FIRECLAY, dark (weak, takes poor glaze)	6	0
Coal	...	9
FIRECLAY, dark (weak, for pipes)	4	6
Bench Coal	3	0
FIRECLAY, light (good, firebricks)	4	6
Coal ["Chip" Coal]	...	9
Dark bind (not proved for pipes)	8	0
Stone	1	6
Mixed bind and light clay	10	0
Coal	3	6
Mixed bind	8	0

The dip is about 18° to 20° towards the west.

Products: At the adjoining works the clays are variously mixed, and made into firebricks and hollow fireproof blocks, quarrels, sanitary pipes, etc. The bricks are used for ship boilers, also in iron-furnaces and kiln-work, etc.

The clays are described as bastard fireclays.

Two other pits in the district belonging to the firm are the Haunchwood, Stockingford, and Heath End, Chilvers Coton, both in Upper Coal Measures.

CHAPTER IX.

POCKET DEPOSITS IN THE PEAK DISTRICT OF
DERBYSHIRE AND ADJOINING PARTS OF
STAFFORDSHIRE, AND IN NORTH
WALES.

DERBYSHIRE.

On the high ground forming the southern part of the main outcrop of the Carboniferous Limestone in Derbyshire are deposits of sand and clay of considerable industrial importance and geological interest. These deposits are found in pockets in the limestone within an area situated south of Monyash and Youldgreave, east of Hartington, west of Winster and limited on the south by the common boundary of the limestone and shales.

The pockets occur without any obvious arrangement, their existence can be proved only by shallow excavations or boring; most of them are found at elevations between 900 and 1,100 ft., but they are usually situated in slight depressions. The deposits vary in size, from small single pipes to large irregular masses, with an area of 100 to 200 square yards, and an unknown depth. The form of the deposits is influenced in some cases by the prevalent direction of jointing in the limestone; occasionally they are in association with ferruginous and lead-bearing mineral veins.

The materials filling the pockets are uniform in character throughout the district, a pale grey, drab or white sandy clay 'ganister' predominates, with this are associated white sands and beds or streaks of white or greenish-white highly plastic clay and pebbles of quartzite, vein quartz and sandstone. In some pits the sands and clays are strongly stained in places with iron oxide, but the bulk of the material is remarkably clean; occasionally a small amount of black clay has been observed. The sands, clays and pebbles often show no regular bedding, but occur in masses without order, on the other hand, steep bedding, inclined towards the centre of the deposit, is observable in places in most of the pits as they are developed; or a well-marked basin-shaped bedding is seen, produced no doubt by the gradual sagging of the contents of the pocket.

The purer white incoherent sands consist almost entirely of angular quartz of all dimensions from minute chips to grains of about 0.3 mm. Mica is not common, and felspar practically absent. There is nothing that can properly be styled argillaceous matter, but each grain of quartz has a pellicle of kaolinitic material. Detrital heavy minerals of the usual nature are moderately abundant.

In the less coherent sands (so-called 'ganister'), which are less pure in composition and colour, the bulk of the material is quartz of similar character to that of the purer samples, but true argillaceous matter is more abundant, and mica and micaceous aggregates are conspicuous. A certain amount of kaolinitic material is present in these sands, also in about the same proportion as in the purer varieties.

The geological age of these deposits is indefinite, possibly post-Triassic and pre-Glacial. The cavities are such as are commonly formed in limestones by subterranean solution, and the nature of their contents points to both Triassic and Carboniferous sources for the sands, clays and pebbles.

Pits are now in operation at Parsley Hay, Friden, Alsop Moor, Brassington, Carsington; others, which are either partially exhausted or difficult to work are at Minninglow, Longcliff and Low Moor.

Reserves in pocket formations are always difficult to estimate, but the evidence of the pits themselves, which descend 60 to 80 ft. into the deposits without showing signs of reduction in their quality, is supported by the records of old lead mining. Thus, near Brassington, the Wester Hollow Mines were dug in a deposit of white sand to a depth of 18 to 30 fathoms; and the Washmere Mine near Friden passed through 35 fathoms of sand and clay without reaching the solid rock. These mines were working carbonate of lead. Moreover, surface indications point to the probability of more pockets being found in the district, as the demand for new sites stimulates further trial boring. The reserves may, therefore, be regarded as ample, both laterally and vertically.

The pockets are always operated as open pits, usually with an inclined tram-line for haulage, with steam or suction gas power. The different grades of sandy clay, argillaceous sand, pebbles, etc., are carefully sorted during the process of digging. Some of the materials are supplied to customers in the raw state or simply ground. The 'ganister' has long been employed as a natural ganister mixture for setting and stopping in furnace work; the purer white sand has been sold for furnace hearths, and special qualities of clay for different purposes in pottery and sanitary-ware manufacture; the yellow argillaceous sands have been tried for steel moulding.

Brick-making plant is adjacent to the pits at Parsley Hay, Alsop Moor, Friden, Brassington and Longcliff. The typical brick made of the local material is a siliceous firebrick. The pebbles are in some cases crushed and added to the brick mixture.

Facilities for transport are provided by the Cromford and High Peak Branch (mineral line) and the Parsley Hay and Buxton Branch of the London and North Western Railway.

STAFFORDSHIRE.

In the same geological district, but within the county of Stafford, sand pits occur in the limestone on the north-western end of the Weaver Hills, about 1 mile south of Caldon village, and $2\frac{1}{2}$ miles by road from Oakamoor. The deposits resemble

those described above, but with the interesting addition of blocks of still undecomposed Bunter Pebble Bed sandstone. These lie in an irregular manner at the side of one of the pits. The sandy clay, pebbly sandstone, etc., are employed together to make a siliceous firebrick at the brickworks at Oakamoor.¹

NORTH WALES.

Deposits of similar character occur in the Carboniferous Limestone near Conway, Halkin, Pant-du, Rhes-v-cae, and other places on the outcrop between Holywell and Bwlchgwyn; also near Llandudno and Abergele. They have been worked intermittently for many years but never so successfully as those in Derbyshire. The material is more sandy than that from the Peak District.²

Derbyshire.

HIGH PEAK SILICA COMPANY.

Parsley Hay, Buxton.

Longdale Pit.

Works: About $\frac{1}{4}$ mile south-east of Parsley Hay Station.

Pits: Longdale Pit, on the north side of Longdale, about $\frac{3}{4}$ mile south-west of Parsley Hay Station.

Maps: One-inch New Ser. Ordnance 111; Old Ser. Geological 81 S.E.; six-inch Derbyshire 27 S.E.

Latitude $53^{\circ} 9' 34''$. Longitude $1^{\circ} 47' 20''$.

The bulk of the material in this pit is white argillaceous sand. Local varieties occur as in all these deposits; thus, some of the sand has a fine even grain and is almost free from clay, though most of it contains sufficient to make a plastic mass when moist; in places the clay preponderates. Pebbles of quartzite and sandstone occur in patches through the deposit, associated in one spot with coarse grit 'rough sand.' A good deal of angular bleached chert occurs near the top on the west side, together with patches of black material.

The sand is hauled up an incline and trammed a short distance to the works.

The pit is about 60 ft. deep; on the north, south and west sides the limestone walls of the swallow hole are visible, a belt of yellow clay appears on the eastern side. There is a cover of 4 to 8 ft. of soil with limestone blocks.

The pit is free on the whole from iron stain, but in wet weather a little yellow clay is washed down to the bottom of the pit from the upper parts and is allowed to settle.

¹ 'The Geology of the Carboniferous Limestone, Yoredale Rocks and Millstone Grit, North Derbyshire.' (*Mem. Geol. Surv.*), ed. 2, 1887, p. 163; and F. Barke, Wheelton Hind and A. Scott, 'Quartzose Conglomerate at Caldon Low, Staffordshire.' *Geol. Mag.*, 1920, p. 76.

² Special Reports Mineral Resources, vol. vi. Ganister, etc. (*Mem. Geol. Surv.*), ed. 2, 1920; and P. G. H. Bowell, 'British Resources of Sands, etc.', 1918; also 'The Geology of . . . Flint, Mold and Ruthin' (*Mem. Geol. Surv.*), 1890.

Reserves: The bottom of the deposit has not been reached, its depth is unknown; laterally this pit is probably not capable of much development, but the firm has proved the existence of other pockets near by.

Products: The raw materials are 'ganister,' *i.e.*, the average grade of argillaceous sand occurring in the pit; 'white sand,' with less clay; and 'best select' white clay, a fine sand with more clay.

At the works the principal output is siliceous brick, hand moulded. The ordinary brick mixture contains ganister (sand) and white clay, with some brick grog and broken quartzite pebbles; to which is added a small amount of the yellow down-wash mentioned above, which gives a warm tint to the fired brick. To special order a white brick is made of the 'ganister' alone. Ganister is sold either raw or ground; it used to be ground *wet* and then dried before transport, for most purposes this has been found unnecessary, and it is now more often merely dried. The white sand most free from clay is used for steel hearths.

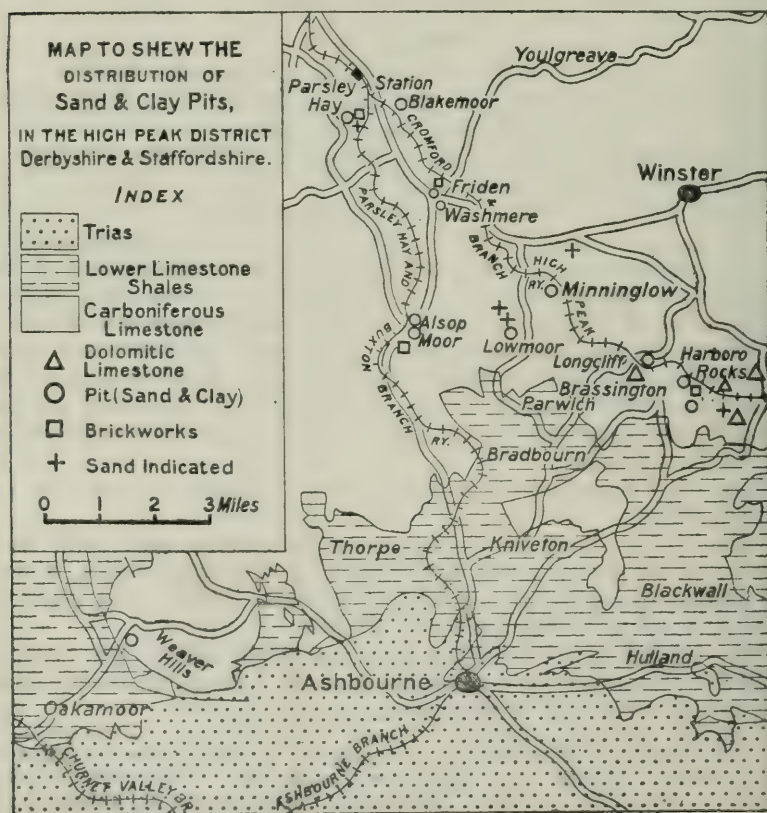


FIG. 7.—Map showing the distribution of Sand and Clay Pits in the High Peak district of Derbyshire and Staffordshire.

HIGH PEAK SILICA COMPANY.

Parsley Hay, Buxton.

Alsop Moor Pit.

Works and Pit: Situated about a mile north of Alsop-en-le-Dale Station, on the Newhaven road near its junction with the road to Hartington. Adjacent to the Buxton Stone and Lime Firm's kilns.

Maps: One-inch New Ser. Ordnance 111; Old Ser. Geological 81 S.E.; six-inch Derbyshire 33 S.W.

Latitude $53^{\circ} 6' 10''$. Longitude $1^{\circ} 45' 41''$.

This pit is about 30 ft. deep, showing on its eastern side a good thickness of hard and firm white argillaceous sand. The northern face exhibits clearly both the steep inward dip of the bedding, about 60° towards the west, and in another part of the face their downward sagging or basin-like curvature, accompanied by some small faults. Some of these beds are stained red or yellow. Six feet of soil forms the overburden, which is sharply marked off from the underlying deposit.

The works are more modern than those at Parsley Hay and are situated immediately outside the pit, but the products and treatment are similar. The argillaceous sand or 'ganister' is hauled up an incline direct from the pit floor to the mills.

THE DERBYSHIRE SILICA FIREBRICK CO.

Friden Station, Hartington, near Buxton.

Friden, Washmere and Blakemoor Pits.

Works: Adjoining the Cromford and High Peak mineral line, on the road from Newhaven to Bakewell.

Pits: The firm is working three pits: *Friden Old Pit*, 200 yards west of the works and just north of Cabins Plantation; *Washmere Pit*, $\frac{1}{4}$ -mile south of the works, near Old House Farm; and *Blakemoor Pit*, $1\frac{1}{2}$ miles N.W. of the works, near Arbor Low.

Maps: One-inch New Ser. Ordnance 111; Old Ser. Geological 81 S.E.; six-inch Derbyshire 28 S.W.

Friden Old Pit: Latitude $53^{\circ} 8' 23''$. Longitude $1^{\circ} 45' 4''$.

Washmere Pit: Latitude $53^{\circ} 8' 15''$. Longitude $1^{\circ} 44' 55''$.

Blakemoor Pit: Latitude $53^{\circ} 9' 50''$. Longitude $1^{\circ} 45' 50''$.

The materials in these pits are of the usual character, white and grey argillaceous sands make up the bulk of the deposit in each. Friden Pit is the largest, about 80 ft. deep and 100 yards square. The following varieties of materials are recognisable in the pit: Grey sand, 'ganister,' white sand (argillaceous), grey clay, white clay, 'soapy' white clay. In the Washmere Pit, which is shallower, from 12 to 30 ft. of grey-argillaceous sand is exposed, there is also a little white clay and some sand almost free from clay. The contents of the Blakemoor Pit are more irregular in character; pebbles which are not abundant at the other two pits are here very numerous, a small amount of black clay and a greenish clay occur.

Reserves: In none of the pits has the deposit been bottomed, and in the case of Washmere, the evidence of old lead mines

points to a large extension in the immediate neighbourhood. The reserves on the firm's property, though not fully proved, should be very large.

Treatment: The raw material from the three pits is sorted at the pits and the works, different grades being stored separately. Some of the clay is dried before grinding and mixing. When prepared, the ground mixture is fed by a bucket elevator on to a belt conveyor which runs over a series of large bins, into which it drops its load as required. The clay is soaked with water while on the conveyor, the wet mass then remains in the bins for about a week; this process is said to facilitate subsequent manipulation.

Products: The works produce three grades of refractory ware:—

- (1) Bricks and shapes and segmental retort blocks containing 91 to 92.5 per cent. of silica.
- (2) Bricks ("B.B." brand) for coke ovens, with 89 to 91 per cent. of silica.
- (3) Siliceous bricks, ordinary grade, containing 85 to 88 per cent. of silica.

SWANN, RATCLIFFE & CO., LTD.

Brassington, Wirksworth.

Brassington Pit.

Works: Brick works adjoining Harboro' Farm on the Cromford and High Peak Mineral Railway; one mile north-east of Brassington.

Pits: Situated close to the works, with which it is in communication by inclined rail.

Maps: One-inch New Ser. Ordnance 111; Old Ser. Geological 72 N.E.; six-inch Derbyshire 33 S.E.

Latitude $53^{\circ} 5' 30''$. Longitude $1^{\circ} 38' 35''$.

The pit lies in a deposit of the usual type; it is from 50 to 60 ft. deep, and contains a large proportion of good workable material. The two principal kinds are white, slightly argillaceous sand, pulverulent when dry, and 'best clay' a drab sandy clay resembling the 'ganister' of the other pits. Subordinate to these are bright yellow loamy sand, possibly suitable for moulding, a white soapy clay (not used at present), greenish clay, and masses of quartzite pebbles. The bedding where visible is almost vertical.

Reserves: In the pit and immediate neighbourhood, large.

Products: Ground ganister, silica sand, and siliceous firebricks. One grade of firebrick is made, but it can be supplied either hand-made or machine pressed.

MR. H. FOWLDS.

65, Devonshire Street, Keighley, Yorks.

Carsington Hill and Longcliff Pits.

Works: Near Longcliff Wharf.

Pits: Carsington Hill Pit, about $\frac{1}{4}$ mile south of Harboro'

Farm. Longcliff pit, east of the Jug-and-Glass Inn, on the Ashbourne-Matlock road, and near Longcliff Wharf, on the High Peak line.

Maps: One-inch New Ser. Ordnance 124 (Carsington), 111 (Longcliff); Old Ser. Geological 72 N.E.; six-inch Derbyshire 33 S.E.

Carsington Pit: Latitude $53^{\circ} 5' 12''$. Longitude $1^{\circ} 38' 20''$.

Longcliff Pit: Latitude $53^{\circ} 5' 50''$. Longitude $1^{\circ} 39' 35''$.

The Carsington Pit is a small one containing the usual type of deposit.

Longcliff Pit, a large old pit from which much material has been taken in the past for firebrick, is now overgrown and little worked.

Minninglow and Low Moor Pits.

Besides the foregoing pits there are others at Minninglow and Low Moor, now in disuse.

Maps: Minninglow and Low Moor. One-inch New Ser. Ordnance 111; Old Ser. Geological 81 S.E.; six-inch Derbyshire 33 N.E. (Minninglow) 33 S.W. (Low Moor).

Minninglow: Latitude $53^{\circ} 6' 50''$. Longitude $1^{\circ} 41' 58''$.

Low Moor: Latitude $53^{\circ} 6' 12''$. Longitude $1^{\circ} 43' 0''$.

The Minninglow pit, situated west of the Low and the mineral railway and south-east of Minninglow Grange, is a large one now overgrown, and the brick works are in ruin; when in working condition it showed a large amount of yellow and red clay and sand resting on white argillaceous sand and sandy clay.

Low Moor Pit, at Low Moor Farm, one mile south-west of Minninglow, is a small pit showing about 30 ft. of whitish sandy clay on the north side with red sand and some black shale on the south.

Staffordshire.

R. & E. BOTTOM.

Oakamoor, Stoke-on-Trent.

Ribden Pits.

Works: Adjoining Oakamoor Station.

Pits: Situated $2\frac{1}{2}$ miles from Oakamoor Station towards Caldon Low, between Ribden Farm and the mine of the same name.

Maps: One-inch New Ser. Ordnance 124; Old Ser. Geological 72 N.E.; six-inch Staffordshire 14 S.W.

Latitude $53^{\circ} 1' 30''$. Longitude $1^{\circ} 53' 0''$.

These pits lie in the hollow parallel with and to the east of the road; the two northern ones are disused, pebbles are abundant in both. The southern, working pit, differs from the others and from the Derbyshire pockets in containing large blocks of pebbly sandstones tumbled down irregularly on the western side; besides these blocks the pit contains material clearly derived from the disintegration of the blocks, pinkish and yellowish sand, pebbles and also some sandy clay.

This deposit being on the hillside, is worked as an open quarry from the flat and the material is carted to Oakamoor.

At the works the stuff is passed between rollers (not edge runners) and mixed for siliceous firebrick. Everything goes into the brick mixture except the largest pebbles. A small quantity of more plastic sandy clay occurs in the pit, this is kept separate, ground wet and then dried and bagged for use as a stopping in gas works. To the materials from Ribden a small amount of dark shale and thin-bedded sandstone ('ganister') from near the firm's brickworks at Froghall is added occasionally, the former to increase the clay portion, the latter to strengthen the silica portion of the brick mixture.

Reserves: Ill-defined, but sufficient for many years at the present rate of consumption.

CHAPTER X.

NORTH STAFFORDSHIRE.

INTRODUCTION.

The Coal Measures of North Staffordshire have been broadly subdivided as follows:—

Upper Coal Measures	...	{	<i>Keele Group</i> —
			Red Sandstones and marls.
			<i>Newcastle Group</i> —
			Grey sandstones and marls.
			<i>Etruria Marl Group</i> —
Middle and Lower Coal Measures.		{	Red marls and green grits.
			<i>Black Band Group</i> —
			Grey shales and marls, thin coals and Black Band ironstone.
Millstone Grit and Pendleside Series.		{	Shales, sandstones and marls, numerous seams of coal and clay, ironstones in the upper part.
			Grits, crowstones and shale.

The Etruria Marls constitute the main source of material for the manufacture of blue, brindled and common bricks and tiles.

The Black Band Group furnishes marls of considerable importance, they are employed for a variety of purposes. Marls are associated with the Hoo Cannel; the one below this bed was formerly employed in the manufacture of "Queen's" ware; below these come the Bassey Mine, 'Howson' and Peacock Marls, the last being used for sanitary ware. Then follow the Great Row Marl, used for pottery purposes, the Cannel Row, Chalky Mine, Knowles, Rusty Mine and Ash Marls.

Marls are associated also with the Moss Coal, Yard, Birches, Stoney Eight Foot, Bowling Alley, Holly Lane, Hard Mine, Ironstone, Eight Foot Banbury and King Coals.

These marls present many variations in quality, and their careful selection for particular purposes is a constant occupation of the manufacturers. Few, if any, show high refractory qualities.

Fireclays occur above and below the Half Yard Ironstone, and Bassey Mine Coal, above the Knowles Coal and Ash Coal and beneath the Burnwood Coal.¹ The Single Four Foot, Rough Seven Foot and Birches Coals are accompanied by fireclays. The Holly Lane Coal has a fireclay locally, and on the west side of the coalfield the Eight Foot Banbury has a good fireclay. In the lower part of the Measures fireclay overlies the Winpenny Coal and underlies the Bee Coal.²

The making of saggars is naturally a very important industry

¹ See J. F. Stobbs 'The Marls and Clays of North Staffordshire.' *Trans. Ceramic Soc.*, xvi, part 1, 1917, p. 107.

² 'The Geology of the North Staffordshire Coalfields.' *Mem. Geol. Survey*, 1905.

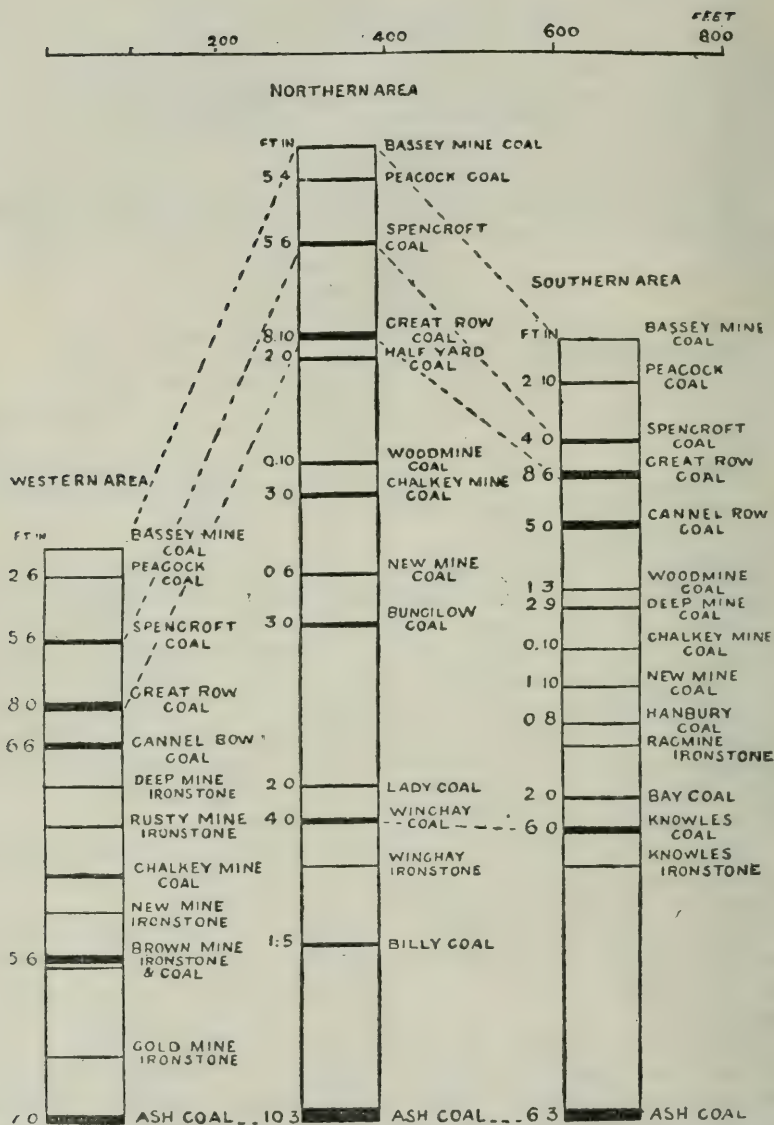


FIG. 8.—Comparative Sections of the Chief Seams of Coal between the Ash Coal and the Bassey Mine Coal.

in this district. The materials used for this purpose are principally the marls below the Bassey Mine and Peacock Coals.

Cobridge Marl Pit, Cobridge.

Character of Strata.	Thickness. Ft. In.
<i>Black Band Group.</i>	
White clay	5 0
Grey limestone	1 2
Grey marls with nodules of siderite	15 0
Grey marl	5 0
Shale with coal smuts	6
Grey marls with nodules containing plant remains..	14 0
Grey marls with nodules of siderite and black lines	8 0
BASSEY MINE IRONSTONE	6 0
BASSEY MINE COAL	2 0
<i>Upper portion of Chief Coal-bearing Group.</i>	
Fireclay	2 0
Grey marls with nodules of siderite	13 0
LITTLE ROW COAL	1 6
Black shale	1 6
Grey marl	9 0
Black shale	4
Grey marls with nodules of siderite	10 0
Hard grey grit	1 0
Grey marls with nodules of siderite	9 0
Grey marls	8 0
PEACOCK COAL	—

In the neighbourhood of Mow Cop some of the shales in the Pendleside Series have been used for ground clay and ganister mixture.

Fireclay Workers in the Pottery District.

- Cannon Street Brick Company, The, Cannon Street, Hanley.
 Clive Brothers, Marl Manufacturers, Cartlidge Street, Tunstall.
 Cobridge Brick and Marl Company, Ltd., Firebrick and Marl Manufacturers, Cobridge.
 Floyd & Company, Weston Coyney, Longton.
 Hampton, E., & Sons, Brick Manufacturers, Eastwood and Mousecroft
 Firebrick and Marl Works, Regent Road, Hanley.
 Hewitt, Joseph, & Sons, Brick Manufacturers, Fenton Low, Fenton.
 Noden & Co., Cobridge.
 Oldfield Brick and Marl Company, Brick Manufacturers, Duke Street, Fenton.
 Patent Hydraulic Saggars Brick and Marl Company, Ltd., Boundary Street, Hanley.
 Scotia Marl Company, Ltd., The, Scotia Bank, Burslem.
 Shaw & Swifts, Brick Manufacturers, Ayshford Street, Longton.
 Shelton Iron and Steel Company, Cobridge Road Brick Works, Stoke-on-Trent.
 * Slaters, Berryhill, Fenton.
 Sneyd Brick Works, Ltd., Brick Manufacturers, Nile Street, Burslem.
 Stephens Brothers, Brick Manufacturers, Queen Street, Fenton.

CHAPTER XI.

SOUTH STAFFORDSHIRE AND NORTH WORCESTER-
SHIRE DISTRICT.

INTRODUCTION.

In this district the fireclay industry appears to have originated in the 16th century, in the neighbourhood of Stourbridge, on the south-western borders of the South Staffordshire Coalfield. According to local tradition it was introduced about 1556 by some refugee Hungarian glass-makers, who found that the fireclays in the local Coal Measures were such as they needed for their melting-pots. It was not, however, until 1786 that the fireclay received any serious attention. At that time the known area was about 200 acres, while the principal makers were Hickman, Waldron, Lord Foley and Lord Dudley. The clay then fetched 34s. a ton, delivered at Stourport, whence it was sent to Bristol for export to all parts of the world. In 1852 the industry had grown to such an extent that about 14 million bricks were made in the Stourbridge district, equal to a consumption of about 46,000 tons of clay, for the best qualities of which the price had advanced to 55s. a ton¹. Since then the industry has spread eastward towards Halesowen and northward beyond Dudley, and 'Stourbridge firebricks' have long enjoyed a world-wide reputation for excellence.

In 1861 the output of 'Staffordshire' fireclay (probably in the main from the Stourbridge district²) was 187,500 tons. In 1873 the output from the Stourbridge district was 124,447 tons, Lye leading with 30,000 tons. In 1874 the amount raised was 258,792 tons. In 1868 there were 16 firms, in 1874 there were 20, producing fireclay goods, the names of the proprietors being in most cases the same as at the present day.³ The firms in 1916 numbered about 26, and several of these owned more than one factory.

The bed of clay originally used was probably the Old Mine clay, which appears to have been exploited first in the Lye district. As this bed became exhausted or less easily accessible, others below it, called the New Mine clays, were brought into requisition, though none of these attains the excellence of the Old Mine clay for the manufacture of such special articles as glass-house pots.

¹ See an article in the "Iron and Coal Trades Review," 15th May, 1908.

² Stourbridge is in Worcestershire; but the Stourbridge fireclay district lies partly in that county, partly in Staffordshire, the river Stour forming the boundary between the two counties.

³ Since 1882 the Home Office Statistics of Output do not give the figures for separate producers of fireclay.

The chief coal-seams in the southern part of the South Staffordshire coalfield (which extends across the river Stour into North Worcestershire) are as follows, in descending order:—

Brooch Coal.

Thick or Ten Yard Coal.

Upper Heathen Coal.

Lower Heathen or Rubble Coal.

Sulphur or Stinking Coal.

New Mine Coal.

Fireclay Coal.

Bottom Coal.

These seams are distributed at intervals through about 400 ft. of measures, in which ironstones and fireclays are of frequent occurrence. Most of the fireclays form underclays of the coal-seams, but others occupy independent positions and are not associated with any coal.

The following abstract section¹ of the Cuba or No. 2 Pit of the Dibdale Colliery at Lower Gornal near Dudley shows most of the typical sequence in this part of the coalfield:—

				Thickness.		Depth.	
				Ft.	In.	Ft.	In.
Soil and made ground				3	0	...	3 0
Shattery (Thick Coal burnt away)				23	6	...	26 6
Gubbin Ironstone measures				14	5	...	40 11
Heathen Coal				1	11	...	42 10
Measures				20	8	...	63 6
White or New Mine ironstone				5	6	...	69 0
Pennystone Ironstone measures				17	7	...	86 7
Coal, 3 ft. 4 in.				6	1	...	92 8
Slums [batty coal], 1 ft. 8 in.							
Coal, 1 ft. 1 in.							
Grey rock, in some places with a little fire-clay (said to represent the Old Mine clay)				6	6	...	99 2
Ironstone and slums				5	6	...	104 8
Fireclay rock (not workable)				5	8	...	110 4
Brown rock and bats				5	9	...	116 1
New Mine Coal.	Coal, 1 ft. 4 in.	{ Top New Mine Coal, }		1	11	...	118 0
	Parting	{ working }					
	Coal, 7 in.	{ working }		1	8	...	119 8
	Bats and fireclay	{ working }					
	'WASTE' CLAY (waste and gob), good fireclay, working				3	4	...	123 0
Bats				1	1	...	124 1
Coal: Bottom New Mine Coal, working				1	9	...	125 10
TOP FIRECLAY ('best' clay), working				5	6	...	131 4
Bind, rock, bat				10	10	...	142 2
Strong grey fireclay rock				1	5	...	143 7
Bats				0	5	...	144 0
Coal [Fireclay Coal?] workable				2	0	...	146 0
Fireclay, workable				1	0	...	147 0
Strong white rock				10	4	...	157 4
Fire-clay	Coal, 1 ft. 10 in., working	{ Bottom Coal? }		9	7	...	166 11
	Slums and bat (in shaft only)						
	1 ft. 6 in.						
Coal.	FIRECLAY, 2 ft. 4 in., working			9	7	...	166 11
Coal and bat, 1 ft. 6 in. working							
Fireclay, 1 ft. 11 in., workable				9	7	...	166 11
Coal, batty, 6 in.							

¹ Communicated by Messrs. B. Gibbons, Junr., Ltd.

	Thickness.		Depth.
	Ft.	in.	Ft. in.
Bottom Fireclay, workable	4	8	171 7
Fireclay, rocky (not workable)	1	10	173 5
Rock, fireclay, ironstone, etc.	16	7	190 0
Fireclay (not workable)	3	3	193 3
Rock and fireclay	2	0	195 3
Rock, grey, strong and pebbly	6	7	201 10

Bottom of shaft.

From this section it appears that fireclays, generally workable, occur as underclays below the Sulphur and lower coals, and under the constituent bands of what we take to be the Bottom Coal; while other clays, approaching them in character, occupy intermediate and independent positions, especially below the Bottom Coal.

Turning now to the Stourbridge area, $4\frac{1}{2}$ miles to the south of Gornal, we find that the coals lower than the Heathen Coal are either absent, or too thin and impure to be workable. The Sulphur Coal and the others that should follow below are not mentioned in the shaft sections, while the various fireclays are recorded under the names Old Mine Clay and New Mine Clays. Moreover, the fireclays under the Heathen Coal—which in this area is divided into two—are valuable clays. These changed conditions are shown in the section of Messrs. John Hall & Co.'s pit at Amblecote, given on p. 122, and in the following abstract section¹ of No. 4 Pit, New Farm Mines, Hungary Hill:—

No. 4 Pit, Hungary Hill, Stourbridge.

	Thickness.		Depth.
	Ft.	In.	Ft. In.
Made ground and measures	176	0	176 0
Brooch Coal	1	6	177 6
White earth	27	0	204 6
Thick Coal (in five parts with thick partings)	85	3	289 9
Dark ground and rock	9	6	299 3
Upper Heathen Coal	2	0	301 3
FOUR-FOOT EARTH (fireclay)	3	0	304 3
Rock and blue earth	17	0	321 3
Lower Heathen Coal	2	0	323 3
BOTTOM ROCK (fireclay)	3	0	326 3
Rock spoil	5	1	331 4
Broad Earth (fireclay)	1	6	332 10
OLD MINE FIRECLAY	4	6	337 4
Rock	33	0	370 4
NO. 1 NEW MINE FIRECLAY	4	0	374 4
Red rock, dark ground and parting	55	0	429 4
Broad earth	1	6	430 10
NO. 2 NEW MINE FIRECLAY	6	6	437 4
Black and red rock	5	6	442 10
NO. 3 NEW MINE FIRECLAY	6	6	449 4
Dark parting	1	6	450 10
NO. 4 NEW MINE FIRECLAY	1	6	452 4
White and green rock, dark ground, dark parting	21	4	473 8
Dark ground	1	3	474 11
Dark parting	0	3	475 2
NO. 5 NEW MINE FIRECLAY [? No. 3 New Mine Fireclay]	2	10	478 0
Red-stained rock	1	0	479 0
Strong green rock	1	0	480 0

¹ Communicated by Messrs. Rufford & Co., Ltd.

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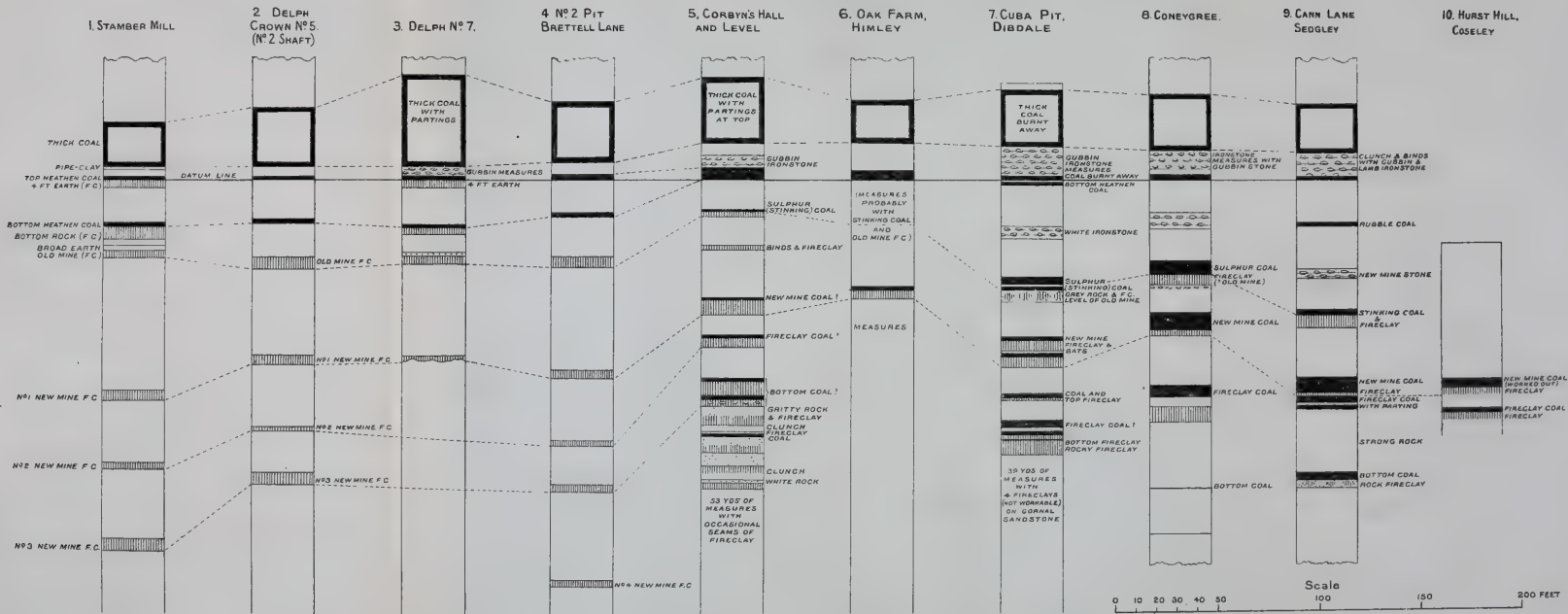
LAY

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VERTICAL SECTIONS FROM STAMBER MILL, THROUGH SHUT END, GORNAL, TIPTON AND COSELEY.



In this mine the underclays of the Upper and Lower Heathen Coals are valuable fireclays. But the Old Mine Clay, with its upper part, the Broad Earth, is not overlain by coal, and the same is the case with the New Mine Clays. This apparent absence of coals unfortunately makes it impossible to ascertain the exact positions of the clays in the general sequence. There are, however, dark partings and dark ground over Nos. 4 and 5 New Mine Clays. It is noteworthy also that the Nos. 2, 3 and 4 New Mine Clays are divided by only 7 ft. of measures.

In an adjacent pit (New Farm No. 1) a foot of 'dark batt' overlies No. 1 New Mine Clay, 15 in. of 'dark ground' overlies No. 2, and a 'black parting' 2 in. thick overlies No. 3.

The question then arises whether any of these dark 'partings,' 'batts' and 'grounds' represent the coals of the more northerly areas as exemplified in the section of the Cuba Pit (p. 142) at Lower Gornal.

Incidentally it is open to question whether the New Mine Clays are in all cases correctly identified in the Stourbridge area: No. 3, for instance, at one pit may not necessarily be identical with the clay called No. 3 at another pit.

Some light on these problems is thrown by the series of Vertical Sections forming Plates I and II, and by the following considerations.¹

Taking first the Old Mine Clay, we have seen that at Lower Gornal the underclay of the Sulphur Coal is regarded as the debased representative of the Old Mine Clay. In the same area, at Coneygree, a mile north-east of Dudley, the Sulphur Coal overlies $3\frac{1}{2}$ ft. of fireclay, with the New Mine Coal still lower. In a trial-pit sunk in 1828 at Sedgley Hall, north-west of Dudley, the Stinking Coal, $4\frac{1}{2}$ ft. thick, overlies "batt 3 in., white clunch 3 ft., Stourbridge fireclay 3 ft. 9 in." The last item doubtless means that the sinkers and others identified the bed with the Old Mine Clay. At Shut End, Kingswinford, a stinking coal overlies a gritty fireclay, while a still lower coal is identified as the New Mine Coal.

Coming nearer to Stourbridge, at Homer Hill Colliery, near Cradley, a bed of batts and batty stinking coal, $4\frac{1}{2}$ ft. thick, in places overlies the Old Mine Clay.

There is a good case, therefore, for the suggestion that the Old Mine Clay is identical with the underclay of the Sulphur Coal.

With regard to the New Mine Clays it is open to doubt, as already remarked, whether all the clays bearing a given number at the different pits are identical. At the Cuba Pit, Lower Gornal, the 'Waste Clay' so called because got from the waste or gob of the Top New Mine Coal, forms part of the underclay of that seam. The Top Clay similarly forms the underclay of the Bottom New Mine Coal. These clays taken together may be identical with the No. 1 New Mine Clay of the Stourbridge

¹ See also Prof. W. S. Boulton, 'The Cores of South Staffordshire and its Borders,' *Trans. Ceramic Soc.*, vol. xvi (1916-17), pp. 237-258 (1917).

district. The Top Clay is 38 ft. 8 in. below the Sulphur Coal, and 88½ ft. below the Heathen Coal.¹

In the Kingswinford, Himley and Pensnett area a clay known as the Himley Fireclay underlies what is identified as the New Mine Coal—here forming a single band—but it is only 56 ft. below the Heathen Coal at the Himley Fire and Red Brick Co.'s pits. At the No. 9 Oak Farm pit this distance is 62 ft. The Sulphur Coal is not mentioned in the sections. At Shut End the underclay of the New Mine Coal is worked at a depth of 36 ft. below the Sulphur Coal (which is mentioned in old records), and 63 ft. below the Heathen Coal. It is probable, therefore, that the Himley Fireclay is correctly identified as the underclay of the New Mine Coal.

Coming still further southward into the Brettell Lane and Delph area, where coals below the Lower Heathen cease to be recorded, we find that the No. 1 New Mine Clay lies below the Old Mine Clay at distances varying from 47 to 62 ft., the average at four pits being 54 ft., a figure in excess of the Shut End measurements. The distance below the Lower Heathen Coal at the same four pits varies from 67 to 83 ft., the average being 74 ft., again in excess of the Shut End figures.

In the Amblecote, Lye and Cradley area, No. 1 New Mine Clay lies below the Old Mine Clay at distances varying in six pits from 32 to 68 ft., the average being 51 ft. In four pits the distance below the Lower Heathen Coal is 51 to 86 ft., the average being 72 ft. The only instances in this area where a coal overlies the clay are at Lower Delph, where there is a sulphur coal about 1 ft. in thickness, and at Netherend, where 10 in. to 11 in. of inferior coal, called the New Mine Coal, are present.

At Hungary Hill, Stourbridge, No. 1 New Mine Clay lies 36 ft. below the Old Mine Clay and 50 ft. below the Lower Heathen Coal; and in one of the pits it is overlain by a foot of dark batt.

The probabilities point on the whole to the conclusion that No. 1 New Mine Clay is identical with the underclay of the New Mine Coal throughout the whole district, from Gornal to Stourbridge.

The case of the No. 2 New Mine Clay is more doubtful. At the Cuba Pit, Lower Gornal, what is probably the Fireclay Coal overlies a workable fireclay, 1 ft. thick, the base of which is 15 ft. 8 in. below the Top Fireclay, which we take to be part of the New Mine Fireclay. The distances below the Old Mine Clay and Lower Heathen Coal are respectively 48 ft. and 104 ft. At Shut End, the underclay of the Fireclay Coal lies 11½ ft. below the New Mine Fireclay, 43 ft. below the underclay of the Sulphur Coal, and 78 ft. below the Lower Heathen Coal. The last figure compares badly with the Lower Gornal measurement, and a thinning has evidently set in between the Sulphur and the Heathen Coals. In the Brettell Lane and Delph area the depths below the No. 1 New Mine and the Old Mine Clays, on an average

¹ These and other measurements refer to the bases of the beds in question.

of three pits, are 38 ft., and 91 ft., while the depth below the Lower Heathen Coal at one pit is 105 ft. In the Amblecote, Lye and Cradley area No. 2 New Mine Clay lies 25 to 58 ft., or, on an average of four pits, 41 ft., below No. 1; 57 to 112 ft., or on an average 91 ft., below the Old Mine; and 76 to 120 ft., or on an average of three pits, 103 ft., below the Lower Heathen Coal. At Hungary Hill, Stourbridge, No. 2 New Mine Clay lies 63 ft. below No. 1, 100 ft. below the Old Mine, and 114 ft. below the Lower Heathen Coal. But it is doubtful if in this area the clays called Nos. 2, 3 and 4 are identical with the clays similarly numbered in the Amblecote, Lye and Cradley area. For in the No. 4 New Farm pit at Hungary Hill these three clays are crowded together, as shown in the following section:—

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
No. 2 New Mine Clay...	6	6	437	4
Black and red rock ...	5	6	442	10
No. 3 New Mine Clay...	6	6	449	4
Dark parting ...	1	6	450	10
No. 4 New Mine Clay...	1	6	452	4

In the closely adjacent No. 1 New Farm pit, the section is as follows:—

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
No. 2 New Mine Clay...	7	0	426	11
Dark clay ...	1	0	427	11
Light strong rock ...	8	0	435	11
Black parting ...	0	2	436	1
No. 3 New Mine Clay...	7	6	443	7

No. 4 clay was not reached at 20 ft. still lower. It therefore looks as if the clays called 3 and 4, or even 2, 3 and 4, in No. 4 pit are the equivalents of 3, or even 2 and 3, in No. 1 Pit, and on the latter assumption it follows that they represent only No. 2 New Mine Clay of the Amblecote, Lye and Cradley area. The distance below No. 1 would then be 78 ft.; below the Old Mine Clay, 115 ft., and below the Lower Heathen Coal, 129 ft. It is possible, however, that in No. 4 pit the clays numbered 3 and 4, and in No. 1 pit the clay numbered 3, are new and independent clays not present elsewhere.

The figures given above do not warrant a very definite conclusion, but they make it probable that in most cases the No. 2 New Mine Clay is the underclay of the Fireclay Coal; and the 'batts' and 'dark ground' overlying the clay in some of the sections may be interpreted as degenerate representatives of the coal itself.

If No. 2 New Mine Clay is identical with the underclay of the Fireclay Coal, it is possible that No. 3 is that of the Bottom Coal. At the Cuba Pit, Lower Gornal, the Bottom Fireclay, under what is identified as the Fireclay Coal but is perhaps more likely to be the Bottom Coal, is 21 ft. below the supposed Fireclay Coal, 47 ft. below the Top or New Mine underclay, 67 ft. below the Old Mine Clay, and 124 ft. below the Lower Heathen Coal. Passing over the Shut End area, for which no figures are available, and coming to the Brettell Lane and Delph area, we

find that on an average of two pits, No. 3 is 24 ft. below No. 2, 56½ ft. below No. 1, 107 ft. below the Old Mine Clay, and 129½ ft. below the Lower Heathen Coal. Some of these figures compare closely with those of Lower Gornal.

In the Amblecote, Lye and Cradley area three pits yield the following figures for the depth of No. 3 New Mine Clay:—

Below No. 2 New Mine Clay—38, 42, 87 ft.—average, 56 ft.
 Below No. 1 New Mine Clay—71, 69, 130 ft.—average, 90 ft.
 Below Old Mine Clay—140, 99, 178 ft.—average, 139 ft.
 Below Lower Heathen Coal—155, 118, 200 ft.—average, 158 ft.

These figures show wide variations among themselves. The average depth of No. 3 below No. 2 has increased by 32 ft., and on deducting this increase from the averages given above, we have the following figures: 24 ft., 58 ft., 107 ft., 126 ft., which are almost identical with the Brettell Lane and Delph figures. At Hungary Hill, Stourbridge, what is called No. 5, but which may be No. 3 of the Lye district, is 26 ft. below the group made up of Nos. 2, 3 and 4, which we have suggested may be No. 2 elsewhere.

On the whole the cumulative evidence is in favour of the identity of No. 3 New Mine Clay with the underclay of the Bottom Coal.

If this is so, Nos. 4 and 5, and other still lower clays that go by the name of New Mine Clays, are independent clays nowhere associated with any coal-seam. At Brettell Lane, No. 4 clay is 45 ft. below No. 3; at Amblecote the distance is 41 ft., while No. 5 lies 37 ft. still lower.

The conclusion of the whole matter may be tentatively stated as follows:—

1. The Old Mine Clay is identical with the underclay of the Sulphur Coal.
2. While the various New Mine Clays can generally be correlated among themselves, in some cases a given New Mine clay at one pit may not be identical with a similarly-numbered clay in an adjacent pit.
3. No. 1 New Mine clay is almost certainly identical with the underclay of the New Mine Coal.
4. While Nos. 2 and 3 New Mine Clays are probably identical respectively with the underclays of the Fireclay and Bottom Coals, the other still lower New Mine Clays are independent clays nowhere associated with any known coal-seam.

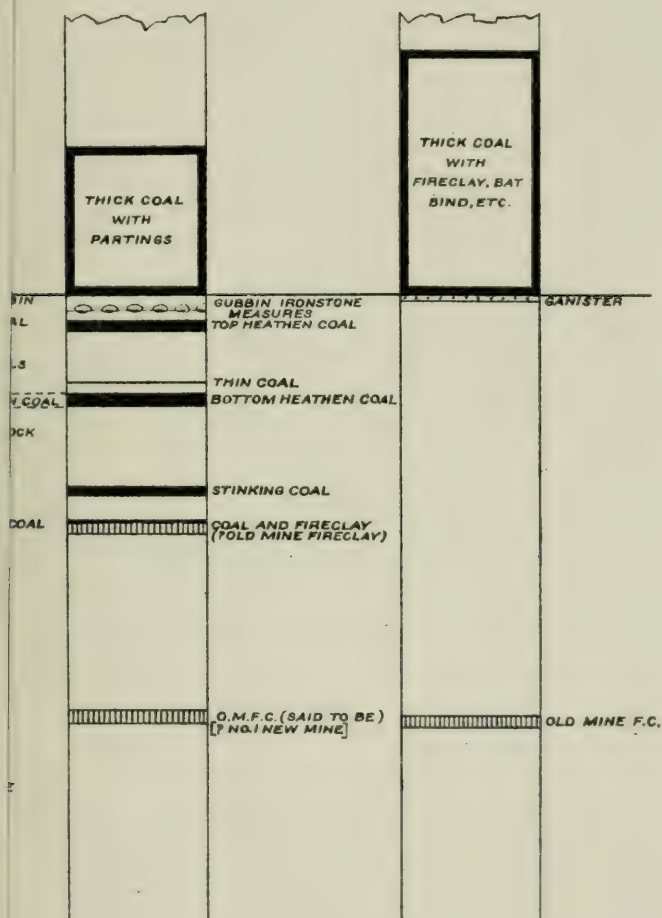
In this connexion it should be noted that, in respect of quality and the uses to which they can be put, the fireclays associated with the Fireclay and Bottom Coals are similar to Nos. 2 and 3, and the still lower New Mine Clays.

These conclusions are expressed in the following column, in

TO WITLEY.

6. CRADLEY HEATH.

7. WITLEY.



1. STAMBER MILL

2. LOWER DELPH.

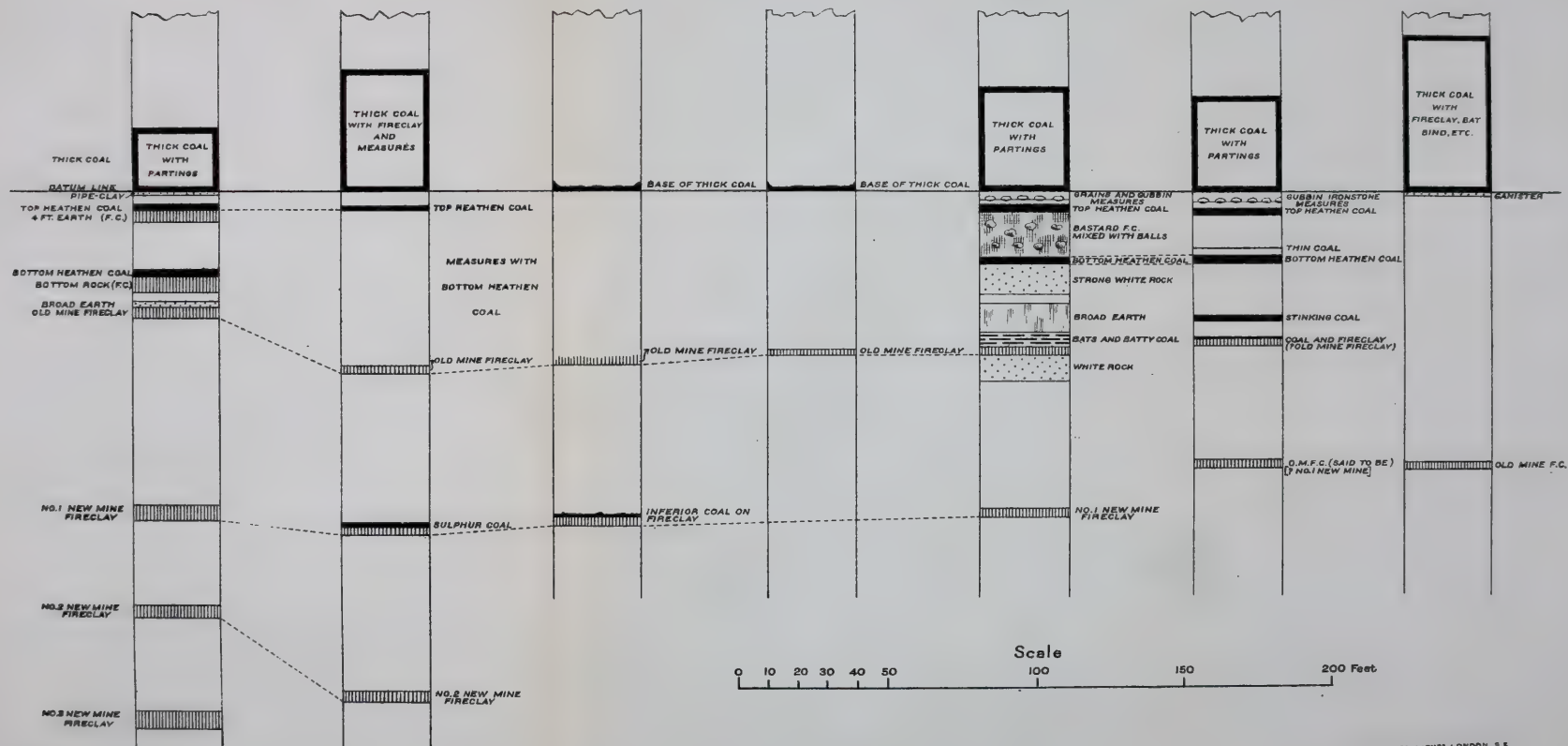
3. NETHEREND.

4. CRADLEY PARK.

5.HOMER HILL.

6. CRADLEY HEATH.

7. WITLEY.



which the names of the coals that are absent in the Stourbridge district are enclosed in square brackets:—

Brooch Coal.	[New Mine Coal]
Thick Coal.	No. 1 New Mine Clay.
Upper Heathen Coal.	[Fireclay Coal]
FOUR-FOOT EARTH.	No. 2 NEW MINE CLAY.
Lower Heathen Coal	[Bottom Coal.]
BOTTOM ROCK.	No. 3 NEW MINE CLAY.
[Sulphur Coal.]	No. 4 NEW MINE CLAY.
BROAD EARTH.	No. 5 NEW MINE CLAY.
OLD MINE CLAY.	Other New Mine Clays.

Structure:—The fireclay district of South Staffordshire is bounded on the west by the western boundary fault of the coal-field (Fig. 9), which throws down the so-called Permian rocks and various members of the Trias against the Middle Coal Measures. The Stourbridge area is crossed by several folds, which, ranging in a general north-east and south-west direction, are traceable by the winding course followed by the outcrops of the Thick Coal and other seams. Taking these folds in order from east to west, the first is the Netherton Anticline, which runs from Netherton south-south-westward to Lye, a distance of three miles. This is followed by the so-called Stourbridge Basin or Syncline, which passes by the Thorns and Tintam Abbey and through Hay Green to the boundary-fault at Hungary Hill. Next follows the Peter's Hill Anticline, which is truncated on the south-west by the same fault. The Thick and Heathen Coals and the various fireclays are thus brought up to or near the surface over a considerable area, a circumstance that enabled the fireclays to be worked with little difficulty. But as the clays are followed to the deep the accumulation of underground water in the Cradley district on the east of the Netherton Anticline, and in the Stourbridge basin on the west, threatens, unless a comprehensive drainage scheme is promptly adopted, to arrest, as it already severely hampers, the exploitation of large reserves of valuable fireclays.

South-west of Dudley the Russell's Hall Fault, here an up-throw of 120 ft. to the north-east, crosses the district and brings up the Thick Coal to the surface. The outcrop of this seam has been traced from Lower Gornal, past Dudley, and along the eastern sides of the Silurian anticlines of Dudley Castle, the Wren's Nest, and Sedgley, towards Wolverhampton.

CLAYS ABOVE THE THICK COAL.

In the Brettell Lane district a good clay has been found beneath the Brooch Coal, with 66 per cent. of silica, but up to the present it has been worked only on a very small scale.

CLAYS IN THE THICK COAL.

At Witley Colliery, south-east of Cradley, the Thick Coal, which, a mile to the north and west, is from 11 to 12 yards in thickness (including thin partings), has swollen out into a series of about ten different bands of coal, separated by partings in

some cases several feet thick, the whole series amounting to 19 yards. Some of these partings are workable batts and fireclays suitable for making refractory goods, sanitary wares and pottery.

This splitting of the Thick Coal of the Dudley-Stourbridge area at Witley is accentuated in the north of the coalfield, about Essington and Wyrley¹. It might, therefore, be worth while to re-examine some of the more northerly parts of the coalfield to ascertain whether the representatives there of the Thick Coal are accompanied by refractory or pottery clays similar to those at Witley.

CLAYS ASSOCIATED WITH THE HEATHEN COALS.

The seat-earths of the Heathen Coals have a certain economic value in the Brettell Lane, Amblecote, and Lye areas, although they are apparently useless in the more northern areas.

The Four-Foot Earth, beneath the Upper Heathen Coal, is usually about 4 ft. in thickness, but it is often siliceous and makes an indifferent firebrick. In one case it is sent to the North Staffordshire Potteries for making saggars, the included iron being extracted with magnets.

The Bottom Rock, beneath the Lower Heathen Coal, is workable in some places, whilst in others it is useless. At Lye, on the southern end of the Netherton anticline, it is almost as good as the Old Mine Clay, whereas in other districts it is siliceous enough to be made into siliceous firebricks, or employed as an addition to fireclay to reduce the shrinkage, etc.

THE OLD MINE CLAY.

The typical district in which the Old Mine Clay is present may be considered as two tracts separated by the Netherton Anticline, viz., (1) the Brettell Lane, Delph, Amblecote and Lye areas; (2) The Cradley area. See Fig. 9.

(1) In this tract the Old Mine Clay usually varies in thickness from about 3 ft. 6 in. to 5 ft. 6 in. Where the thickness is below the average the seam is occasionally overlain by the Broad Earth (in some mines a fireclay of economic value), which may represent the top of the Old Mine Clay in those places where the latter is at its thickest.

The Old Mine Fireclay, which at Amblecote is 3 ft. 7 in. in thickness, increases rapidly to 6 or 7 ft. near the western boundary fault of the coalfield; while eastward, in the direction of the Netherton anticline, the clay becomes definitely thinner than the average for this district, and approximates to the thickness commonly found in the area east of that anticline.

In the west, near Amblecote, the Old Mine fireclay is directly overlain by the Bottom Rock, a siliceous clay forming the seat-earth of the Lower Heathen Coal, although eastward they are separated by from 5 to 15 ft. of measures, including the Broad Earth.

The clay is thickest in the north about Brettell Lane, where

¹ 'The South Staffordshire Coalfield' (*Mem. Geol. Surv.*), ed. 2, 1859, pp. 18-27.

in one case it attains an exceptional thickness of 7 ft. Here, as already stated, the Broad Earth occurs where the Old Mine Clay is thinnest (4 ft.), and appears to represent the higher part of the Old Mine Clay of neighbouring tracts. It is separated from the Lower Heathen Coal by from 13 to 21 ft. of measures, including the Bottom Rock and also the Broad Earth, wherever these are present.

(2) In the Cradley tract, to the east of the Netherton anticline, the Old Mine Clay varies from 2 ft. 9 in. to 3 ft. 6 in. in thickness, and in places is overlain by a stinking coal. Its distance below the Lower Heathen Coal increases at first slowly, and then rapidly till, a little east of Cradley, it becomes 65 ft. or more. A sulphur or stinking coal and another coal occur in this thickening belt of measures (*see* Sections, Pl. II).

Outside the typical district the Old Mine Clay occurs at Shut End, but in such a debased condition that sometimes it has not been detected. At Saltwells ($1\frac{1}{4}$ miles east of Brierley Hill), on the eastern slope of the Netherton anticline, what is called the White Stone (possibly the representative of the Broad Earth), and the Old Mine Clay upon which it rests, have both been occasionally used for making firebricks, but the Old Mine Clay at this point is hardly of such good quality as in the typical area.

Farther north, near Dudley, it has not been detected, while at Gornal it is represented merely as a useless 'grey rock,' sometimes mixed with fireclay, beneath the Sulphur Coal.

In the Tipton and Sedgley area, still farther north, the fireclay underlying the Sulphur or Stinking Coal may represent the Old Mine Clay, but has none of its characteristic qualities.

Thus the Old Mine Clay exhibits its thickest development in the Brettell Lane neighbourhood, where it is of the same high quality as in the Lye and Cradley areas on the two sides of the Netherton anticline. The clay is thinnest east of the anticline.

The seam as a whole deteriorates in quality in a direction north-eastward from Brierley Hill, until it becomes of little or no economic value. Concurrently with these changes the measures between the Lower Heathen Coal and the Old Mine Clay, or its representatives, increase considerably in thickness towards the north-east.

The Old Mine Clay derives its superiority from its relative proportions of silica and alumina, together with its low percentage of alkalis or other natural fluxes. The relative percentages of silica and alumina, however, vary in different parts of the seam, usually in a vertical direction, but horizontally also, and the types of clay resulting must be judiciously selected for the purposes for which they are destined.

In an average section the Old Mine Clay is divisible into three parts:—(a), an upper, almost black, mild and aluminous clay, passing into (b), a central less mild, brownish or dark-grey clay, which grades downwards into (c), a lower pale-grey, strong and siliceous clay.

The black clay may contain 40 per cent. or more of alumina, whilst the remainder contains only about 25 to 28 per cent.

This arrangement into three zones, however, is not always evident, for occasionally only two are recognised—a black clay upon a light-grey clay—the best black being a steel-crucible clay, and the best grey being good for glass-house pots. Again, the dark ‘mild’ top is sometimes of little use, and in one case at least, where the clay is 6 ft. in thickness, the black seam is near the bottom, whilst the top is pale and strong. At one locality the greater part of the seam is a strong siliceous clay containing over 85 per cent. of silica, while at another locality the top of the seam is a thin band of siliceous clay (called the ‘blazer’) suitable for making a siliceous firebrick. Half a mile away the Broad Earth, which merges downwards into a mild black clay, overlies a few inches of similar but impersistent silica-stone, resting on clay apparently of the usual type, but of which the black top is selected for making glass-house pots. In another case the seam is more or less dark all through, and is suitable for making the finest wares.

It is the usual practice to grade the clays into three classes—best, seconds and offals; but it must be clearly understood that this grading depends upon the nature of the clay, and not upon its position in the seam, and in fact, the clay, as we have pointed out before, varies in a lateral as well as in a vertical direction. At one locality the best clay is white, at another it is black. The seconds and offals are used for the coarser and less finished goods.

NEW MINE CLAYS.

Beneath the Old Mine Fireclay in the typical area near Stourbridge there are practically no coals to be met with in a fairly thick series of measures. There are, however, five or more fireclays of varying economic value, termed locally the ‘New Mine Clays.’ Of these, the upper or No. 1 New Mine Clay is the best known.

In some cases one or more of the New Mine clays have been proved but not yet exploited, and occasionally the No. 1 New Mine Clay has not been reached in the shafts.

The No. 1 New Mine Clay, which ranges from 4 ft. to 5 ft. in thickness, is usually light in tint, and, like most fireclays, is subject to great lateral changes in texture and quality, and in the number of included ‘cannocks,’ *i.e.*, nodules of iron-stone. It varies from a useless clay to one rivalling in quality the Old Mine Clay, and is suitable for making glass-house pots and spelter crucibles. Sometimes it is more, sometimes less, siliceous than the Old Mine Clay. Occasionally it is used for making glazed bricks and sanitary wares.

The No. 2 New Mine Clay varies from 3 ft. or less up to 4 ft. 6 in. in thickness, and is sometimes too thin to be worth working. It is a light-coloured fireclay of normal texture and hardness, with the usual variations. Its quality is perhaps not so good as that of the No. 1 New Mine, but it is suitable for ordinary goods.

The No. 3 New Mine Clay has been proved only in the Lye and Brettell Lane areas, where it varies from about 3 ft. 6 in.

to 6 ft. (proved) in thickness. It is now being worked at four mines, and in three other mines has been either worked out or abandoned.

The No. 4 New Mine Clay has been proved in four mines to range up to 4 ft. 6 in. in thickness. It is a strong clay and is worked occasionally.

The No. 5 New Mine Clay has been proved at two localities with a maximum thickness of 7 ft. South of Lye it is a good clay of uniform quality, varying in tint from black above to dark-grey below.

None of these four lower New Mine clays is perhaps equal in quality to the Old Mine Clay, and they are all liable to contain cancocks of ironstone. Some of them are used for making glazed brick, sanitary ware and pottery.

In the northern area the fireclays of the New Mine, Fireclay, and Bottom Coals are the most important of the clays. The two latter are used for making refractory wares of the ordinary type.

GENERAL OBSERVATIONS.

Reserves: As the Old Mine Clay was probably the first seam to be worked, and on account of its high quality is still the most valuable of the local clays, the reserves are necessarily becoming small. Especially is this the case wherever the bed was easily accessible at its outcrop or at shallow depths, and in some of the mines this seam is exhausted. Elsewhere, in districts where the bed lies at greater depths, there are still large reserves of excellent clay, though perhaps not of a quality equal to that in the Stourbridge, Amblecote, Lye and Brettell Lane areas.

The various New Mine Clays constitute a large reserve of material suitable for the manufacture of most classes of refractory goods. In some of the mines one or more of these clays have been exhausted, while the others have scarcely been touched or have merely been proved.

In a general view of the district it can be stated with confidence that in quality and quantity the reserves of fireclay are sufficient for all requirements for many years to come.

The South Staffordshire Mines Drainage scheme, so far as it applies to the fireclay district near Stourbridge, deals with surface water alone, but a voluntary association of firms of firebrick makers and property owners deals with the deep water. A levy is made of one penny per ton on the minerals raised. This scheme keeps the underground water at its present level but is inadequate to unwater the deep parts of the mines, so that although there are large reserves of mineral, unless some comprehensive drainage-scheme is adopted much of this reserve will remain inaccessible.

Winning: In this district the fireclays are generally won by means of shafts; but in a few cases openworks, day-levels, drifts and slants are used.

Working: The clays are worked in much the same manner as the coal-seams, generally on the pillar-and-stall system, but occasionally on the longwall system. Explosives are extensively employed.

Weathering: The clay is tipped on the surface in dumps, tips, or large heaps. In a few cases, where two or more beds of clay are worked at a mine, each clay is tipped separately on its own dump, but this practice is far from general, and at many of the mines the different clays are thrown on to the same heap.

Usually the clay is allowed to weather as long as possible. At the present time (1916) the period allowed for this has to be curtailed on account of the scarcity of underground labour; but in normal circumstances the clays are weathered from 8 months to $3\frac{1}{2}$ years. At some works the period has been $2\frac{1}{2}$ months; at others 10 years. In one case the clay is not weathered at all, while some old dumps at another works have been standing for probably not less than 20 years. It is generally agreed that long weathering is beneficial, as it disintegrates the clay, renders it friable, increases its plasticity, dissolves out iron and alkalies, and frees any ironstone-nodules present from adherent matter and so enables them to be detected and removed. But while these results are obtained on the exposed parts of the dump it is recognised that the effect may be slight in its interior, and there is a tendency now to spread the clay in thinner heaps wherever room is obtainable, and to assist the weather by spraying the heaps with water, or by other processes regarded as trade secrets.

Selecting and Blending: The weathered clays are selected and blended according to the nature of the goods to be made. The Old Mine Clay in particular is graded into three qualities, known as 'best,' 'seconds' and 'offal'; this grading being governed by the character of the clay and not by its position in the seam. The best clay is used mainly for glass-house pots, the seconds for crucibles, and the offals for ordinary firebrick goods.

Grog: The selected and blended fireclays are ground with a suitable proportion of 'grog' or 'chamotte,' added to counter-act shrinkage; or with some form of silica stone, introduced partly for the purpose of raising the silica percentage. The grogs used are (1) burnt fireclay, specially prepared for the purpose by burning lump clay in upright kilns, and (2) waste burnt firebricks and kiln-dust, or firebricks roughly made for the purpose. The silica-stones used are siliceous sandstones such as the Gornal Stone and Bilston Stone from the local Coal Measures, quartzites and sandstones from the 'Millstone Grit' of North Wales, and Cambrian quartzite from the Lickey Hills near Bromsgrove. It is stated also that red sand from the local Trias and Glacial drift is used for the same purpose.

Grinding: The grinding is done under edge-runners revolving in a perforated pan, the motive-power being steam, or, in a few cases, electricity. In most places the ground mixture is then screened, tempered with water in some form of pug-mill or open mixer, and carried to the moulding-shed, where it is moulded by hand into firebricks, furnace-bricks, gas-retorts, glass-house pots, crucibles, etc. At some of the works a part of the clay is moulded by machinery for wire-cut bricks, and such goods as pressed bricks, honeycomb-bricks for hot-blast stoves, gas-retorts, sleeves, stoppers and nozzles, tuyeres, etc.

Drying: The goods are dried on floors heated by coal fires, or by steam (waste or live). The time required depends on the size of the article, ordinary firebricks taking 2 or 3 days, whilst a gas-retort needs as many weeks, and a glass-house pot several months. In one works, where Price's Patent Tunnel Drier is used, the firebricks are placed in tiers on trucks, which are slowly moved from one end of the drier at 80° F. to the other at 150° F.

Firing: The dried goods are fired in downdraught kilns, usually round ('bee-hive'), occasionally oblong. At one works continuous kilns after a German pattern are used (p. 141), while at another the kilns are arranged in series in such a way that the heat given off during the cooling of one kiln is used to dry the bricks stacked for firing in the next.

Pyrometer: The firing temperature and degree to which the firing is approaching completion are judged by seger-cones, trial-bricks, and in one or two cases by pyrometer.

Products: The refractory ware produced in this district is very varied and includes firebricks of various grades and shapes. furnace and cupola bricks, blast-furnace blocks, bricks for hot-blast stoves, coke-oven bricks, light bricks for marine engines, stoppers, nozzles, sleeves, etc., glass-house pots, tanks and blocks. baths and glazed bricks, gas-retorts and retorts of various kinds.

The larger firms usually specialise on one or more of these products. Two firms make a siliceous brick from a strong siliceous band in the Old Mine Clay.

Raw or burnt clay is supplied to spelter works and to makers of steel crucibles, glass-pots, etc.

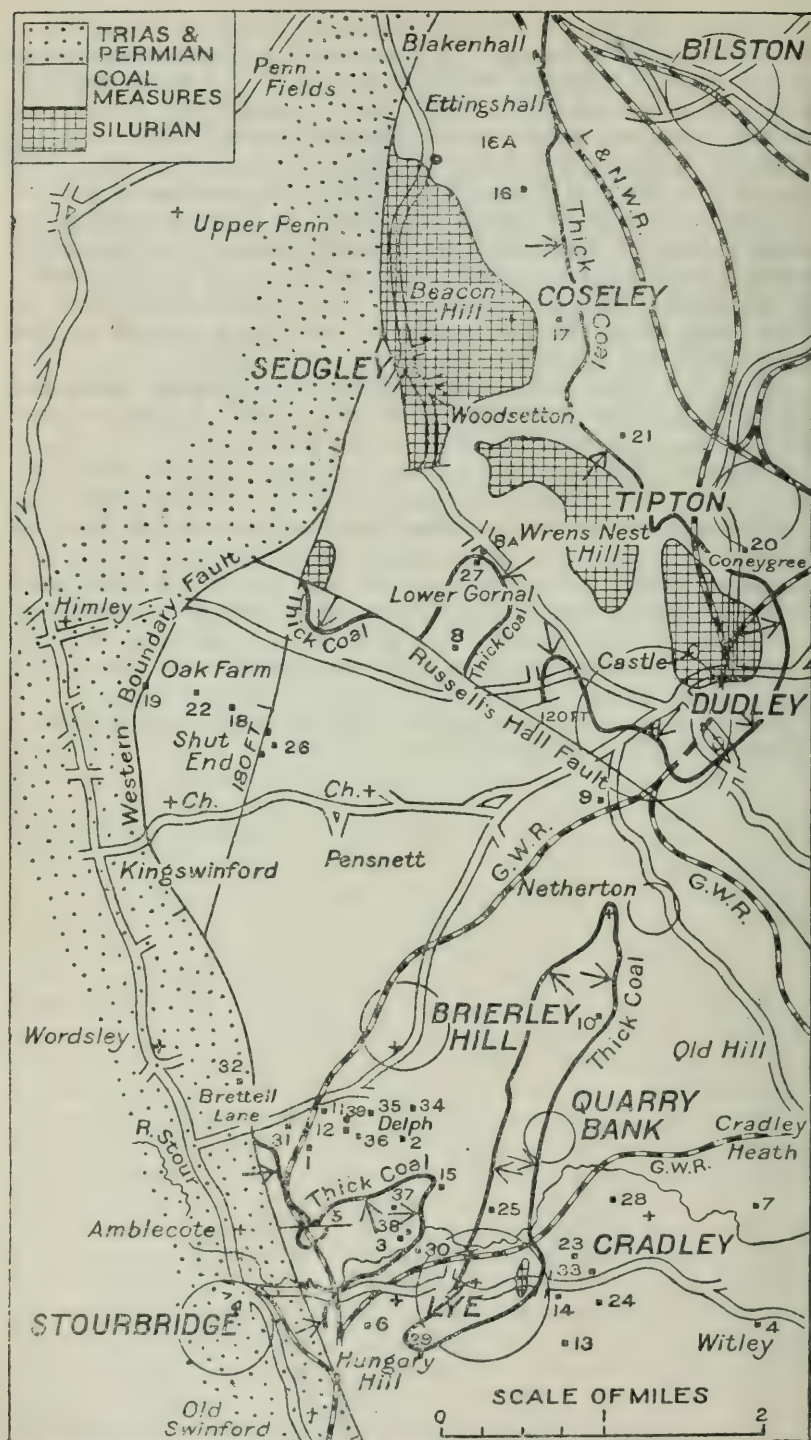


Fig. 9.—Map of the South Staffordshire—Worcestershire Clay area.

KEY TO NUMBERS ON THE MAP. FIG. 9.

No.	NAME OF FIRM.	MINE OR QUARRY. ETC.
1.	Harris & Pearson	Plant's Hollow Mine.
2.	"	Turner's Lane Mine.
3.	Timmis & Co.	Amblecote Bank Mine.
4.	"	Witley Colliery.
5.	John Hall & Co.	Amblecote Bank Mine.
6.	Rufford & Co.	Hungary Hill Colliery.
7.	Mobberley & Bayley	Timbertree Colliery.
8.	B. Gibbons, Junr.	Cuba Pit.
8A.	"	Cartwright's Pit.
9.	Stourbridge Glazed Brick and Fireclay Co.	Thornleigh Pit.
10.	Doulton & Co.	Saltwells Openworks.
11.	Trotter, Haines & Corbett	Brettell Lane Colliery.
12.	Bowen's Successors	Tinker's Field Pits.
13.	Mobberley & Perry	Oldnall Colliery.
14.	"	Hayes Colliery.
15.	"	Thorns Colliery.
16.	J. Bates	Rookery Pit.
16A.	"	Ettingshall Park Openworks.
17.	W. Mobberley	Hurst Hill Colliery.
18.	Himley Fire and Red Brick Co.	Shafts.
19.	J. T. Price & Co.	Himley No. 7 Pit.
20.	J. & S. Baggott	Coneygree Pit.
21.	G. G. Wilkinson & Co.,	Fireclay Mines.
22.	John Walker	Oak Farm No. 9 Pit.
23.	King Bros. (Stourbridge)	Netherend Colliery.
24.	"	Cradley Park Colliery.
25.	"	Delph Nos. 3, 4, 11 and 12 Pits.
26.	Stourbridge Refractories Co.	Shut End Colliery.
27.	J. Waterfield & Son	Upper Gornal Colliery.
28.	Evers & Sons	Homer Hill Colliery.
29.	H. T. Hickman	Huddy Castle Pit.
30.	George K. Harrison	Lye Pit.
31.	"	Brettell Lane Pit.
32.	"	Nagersfield Pit.
33.	Harper & Moores	Lower Delph Colliery.
34.	E. J. & J. Pearson	Delph No. 7 Pit.
35.	"	Iron Jack Pit.
36.	"	Crown No. 5 Pit.
37.	"	New Ravensitch Pit.
38.	"	Freehold Pit.

Black squares show sites of mines.

Crosses show sites of parish churches.

Stourbridge Area.

RUFFORD & CO., LTD.

Hungary Hill, Stourbridge.

Works: At Hungary Hill, $\frac{3}{4}$ mile south-east of Stourbridge.

Mines: Shafts (Hungary Hill, No. 8 Pit.) adjacent to the works.

Maps: One-inch New Ser. Ordnance 167; Old Ser. Geological 62 S.W.; six-inch Worcestershire 4 S.W.

Latitude $52^{\circ} 27' 15''$. Longitude $2^{\circ} 7' 40''$.

Geological formation: Middle Coal Measures. Old Mine Fireclay and New Mine Fireclays.

In the No. 8 Pit the Old Mine Fireclay, 4 ft. 6 in. thick, lies at a depth of $81\frac{1}{2}$ yards.

The raising of fireclays at this colliery has practically come to a standstill. The coal being all worked out, the remaining clays cannot be worked at a profit, owing to the high cost of pumping. A large stock of clay has, however, been raised and remains in the dumps, which are of unusual size.

In addition to the Old Mine Clay, the clays under the two Heathen Coals and the No. 1 to No. 5 New Mine Clays are present, and have all been tried or worked. The No. 1 New Mine Clay has not been worked. In the Bottom Rock under the Lower Heathen Coal there is 2 ft. of good clay, the remainder being full of ironstone-nodules ('canks' or 'cannocks').

Reserves: Large in the dumps.

Mode of working: Both pillar-and-stall and longwall methods have been employed.

Treatment: Weathered for many years. The clay is picked over for the removal of ironstone and other impurities. The Old Mine Clay is graded into three qualities: 'best' or 'firsts,' for glass-house pots; 'seconds' for crucibles; and 'thirds' or 'offals' for ordinary firebrick goods.

Amblecote, Lye and Cradley Area.

JOHN HALL & Co. (OF STOURBRIDGE), LTD.

Amblecote, Stourbridge.

Works: At Amblecote Bank, $\frac{3}{4}$ mile N.E. of Stourbridge.

Mines: Shafts (Amblecote No. 2 Pit), 250 yards S.W. of the works.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Staffordshire 71 S.W.

Latitude $52^{\circ} 27' 47''$. Longitude $2^{\circ} 8' 6''$.

Geological formation: Middle Coal Measures. (Old Mine Fireclay and New Mine Fireclays.)

The following section of the pumping-shaft of No. 2 Pit shows the thicknesses and depths of the more important beds:—

	Thickness.		Depth.	
	Ft.	In.	Yds.	Ft. In.
Thick Coal (near surface)	—	—	—	—
Lower Heathen Coal	1	10	—	—
Parting	—	—	—	—
Bottom Rock	3	4	36	2 6
OLD MINE FIRECLAY (working)	3	7	42	0 1
No. 1 NEW MINE FIRECLAY (working) ...	5	0	52	2 0
No. 2 " " (not now worked)	4	6	61	0 0
No. 3 " " (abandoned)	3	6	75	0 0
Fireclay	4	4	79	2 4
Blue Measures Fireclay (bastard)	8	6	84	0 7
No. 4 NEW MINE FIRECLAY (working) ...	4	6	88	2 1
Fireclay	1	0	97	1 1
No. 5 New Mine Fireclay	7	0	101	0 7
Bottom of shaft at	—	—	106	1 10

The Bottom Rock, separated from the Lower Heathen Coal by a parting, is highly siliceous. No. 1 New Mine Clay is a 'mild' (highly aluminous) clay. No. 4 New Mine Clay is a 'strong' (highly siliceous) clay. The Old Mine Clay, which becomes 6 or 7 ft. thick as it approaches the western boundary fault of the coalfield on the west, consists partly of light-grey ('white'), partly of dark-grey ('black') clay; the latter variety contains 41 per cent. of alumina and is regarded as a 'mild' clay. The New Mine clays are generally light-grey. The Bottom Rock, spoken of as 'silica-rock,' is an incoherent gritty sandstone, which is utilised as a constituent in siliceous fire-bricks.

The measures dip gently northward.

Reserves: Ample. Limited on the west by the boundary fault of the coalfield. Water presents no difficulties.

Mode of working: The Old Mine Fireclay is worked by pillar-and-stall; No. 4 New Mine by longwall.

Treatment: The clays are dumped in separate heaps and weathered for one to four years, and in some circumstances for five years. The process is believed to remove alkalies and iron. Any ironstone-nodules not left underground are picked out at the dumps by women.

The Old Mine Clay is graded into three qualities: 'firsts,' 'seconds' and 'offal.' The best white clay, which is used for making glass-house pots, is worth £3 per ton at the pit-head. Some of this is exported to Australia. The black clay is sold for making crucibles at the steel-works. The so-called 'offal' forms the bulk of the clay, and from this the ordinary fireclay goods are manufactured. Both white and black clays are sold to the Birmingham brassfounders. The grog used consists of burnt white fireclay, and the 'Bottom Rock.'

MOBBERLEY & PERRY, LTD.

Stourbridge.

Situation: There are three brickworks and three principal mines, details of which are as follows:—

Works: The Hayes Works, Lye.

The Hurst Works, Woodside, near Dudley.

The Himley Works, Kingswinford.

Mines: (1) Oldnall Colliery, Lye.

(2) Hayes Colliery, Lye.

(3) Thorns Colliery, Lye.

Maps: One-inch New Ser. Ordnance 167; Old Ser. Geological 62 S.W.; six-inch (Oldnall and Hayes Collieries) Worcestershire 4 S.E.; (Thorns Colliery) Staffordshire 71 S.E.

(1) Latitude $52^{\circ} 27' 8''$. Longitude $2^{\circ} 5' 56''$.

(2) „ $52^{\circ} 27' 23''$. „ $2^{\circ} 5' 57''$.

(3) „ $52^{\circ} 27' 59''$. „ $2^{\circ} 7' 0''$.

Clay is also mined occasionally for use at the Himley works on a leasehold held under Lord Dudley.

At the Hayes works red clay (marly) is dug opencast for the manufacture of blue bricks.

Geological formation: Middle Coal Measures.

The sections at the Collieries are as follows:—

					Thickness.	Depth.
					Ft.	Yds.
<i>Oldnall Colliery—</i>						
Measures	...	...	...	...	521	173 $\frac{1}{2}$
Top Coal 7 ft.	}	Equivalent of	the Thick Coal.	}	19	180
Bottom Coal 12 ft.						
Measures	...	...	...	...	45	195
OLD MINE FIRECLAY (working)	...				3 $\frac{1}{2}$	196 $\frac{1}{2}$
<i>Hayes Colliery—</i>						
Measures with Top Coal and Bottom						
Coal	...	...	...	...	540	180
Measures	...	...	...	...	51	197
OLD MINE FIRECLAY (working)	...				3-4	198
Measures (some coal)	...	...	...	...	30	208
No. 1 NEW MINE FIRECLAY (working)					4	209 $\frac{1}{2}$

Thorns Colliery—

About 50 yards to the Old Mine Fireclay (3 ft.); sinking to No. 1 New Mine Fireclay is in progress.

The Old Mine Clay, which is black at the top, passes downwards through dark-grey to pale-grey. At Hayes Colliery it is more or less black throughout and is especially suitable for making glass-house pots and crucibles. At Thorns Colliery the Old Mine Clay is grey and is used as an ingredient in manufacturing glass-house pots. At Oldnall Colliery the clay varies in colour from black to grey and is of uniform quality throughout.

Reserves: Reserves of the strong siliceous clay from the Old Mine Clay at the Hayes Colliery are estimated at 150,000 tons. Mr. Pearson-Perry estimates that the general reserves of clay will last 100 years.

Mode of working: Both coal and clay are worked on the long-wall system.

Treatment: The clay is weathered on the banks for various periods up to 3 years. The siliceous clay is treated specially. For retorts the grog added is burnt fireclay for furnace-brick mixtures Gornal stone is added.

HARPER & MOORES, LTD.

Lower Delph, Stourbridge.

Works: At Lower Delph, between Lye and Cradley.

Mine: Lower Delph, near the Hayes, with underground extensions towards Colleygate.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Worcestershire 4 S.E.

Latitude 52° 27' 29". Longitude 2° 5' 42".

Geological formation: Middle Coal Measures.

The following is an abstract of the shaft section:—

	Thickness. Yds.	Depth. Yds.
Measures	94	94
Brooch Coal (working)	1	95
Measures	25	120
Thick Coal with Measures (working) ...	14	134
Measures	20	154
OLD MINE FIRECLAY (working) ...	1	155
Measures	17	172
No. 1 NEW MINE FIRECLAY (working)	1	173
Measures	18	191
No. 2 NEW MINE FIRECLAY	1 $\frac{1}{3}$	192 $\frac{1}{3}$
(not worked but workable).		

In the top part of the Thick Coal there is a seam of fireclay, variable in quality, and 10 in. to 2 ft. thick. The Heathen Coals are only 12 to 14 in. thick.

A sulphur coal about a foot thick lies immediately on top of the No. 1 New Mine Fireclay. The beds dip gently eastward.

There are two west-and-east faults in the mine, both with downthrow south. The more northerly has a throw of 8 yards and affects the coals and fireclays; the more southerly one has a downthrow of 10 yards to the south and affects the Thick Coal.

The Old Mine Clay at this locality is very hard and becomes gritty on the south side of the property. The top of the seam is milder, and is used chiefly for glass-house pots and crucibles.

The No. 1 New Mine Clay is milder than the Old Mine Clay and is selected for manufacturing cupola and blast-furnace linings.

Reserves: The output of clay could easily be doubled if demand arose. The reserves are estimated at 7 to 8 acres of the Old Mine Fireclay, 52 acres of the No. 1 New Mine, and 60 acres of the No. 2 New Mine Clay.

Mode of working: The clay is worked on the longwall system. Very little trouble arises from water. There is not much waste, and what there is remains in the workings.

Treatment: Weathering in a few months breaks down the hard clay into a friable mass and releases the small ironstone-nodules ('cannocks'). Bricks made from unweathered clay are friable and abrade quickly, whereas those made of weathered clay are hard and resistant. The clay is left on the banks for six months and would remain still longer if space were available. The grog used is burnt fireclay; some Gornal stone, and grit from Mow Cop near Congleton, are also used.

TIMMIS & Co.

Lye, Stourbridge.

River Stour Works.

Works: (1) River Stour Works at Stamber Mill, 1 mile east of Stourbridge.

(2) Witley Works, on the Halesowen road, 3 miles east of Stourbridge.

Mines: (1) Shaft and day-level at Amblecote Bank, on north bank of the River Stour, one-third of a mile north-by-east of St. Mark's Church, Stamber Mill.

(2) Shafts (Witley Colliery) at the Witley Works.

Maps: Amblecote Bank: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Staffordshire 71 S.W.

Latitude $52^{\circ} 27' 42''$. Longitude $2^{\circ} 7' 21''$.

Witley Colliery: One-inch maps as above; six-inch Worcestershire 4 S.E.

Latitude $52^{\circ} 27' 11''$. Longitude $2^{\circ} 4' 13''$.

AMBLECOTE BANK.

Geological formation: Middle Coal Measures (Old Mine Fireclay, Nos. 1 and 2 New Mine Fireclays).

The Four-Foot Earth under the Upper Heathen Coal occurs in the property, but it has a high silica percentage and makes an indifferent brick.

The dip of the measures is southward.

The section of one of the disused shafts owned by the Company at Stamber Mill is plotted on Plate I, No. 1.

Reserves: Plentiful; the main difficulty arises from underground water.

Mode of working: Pillar-and-stall.

Treatment: The clay is sorted by hand, some being specially selected for such goods as spelter-crucibles and glass-house pots, and the remainder weathered for several months. The grog used consists of fireclay specially burnt for the purpose.

WITLEY COLLIERY.

Geological formation: Middle Coal Measures (Old Mine Fireclay).

The Old Mine Clay, which is 2 ft. 6 in. thick, is 31 yds. 6 in. below the Thick Coal, and is reached at a depth of 319 yds. 1 ft. (Plate II, No. 7). The No. 1 New Mine Clay has recently been proved at about 21 yards below the Old Clay Mine. The general dip of the measures is south-eastward at 1 in 5, decreasing toward the south-east to 1 in 20.

Reserves: Ample. Underground water gives trouble, but a scheme that has the approval of the Coal Controller is now being proceeded with which will afford relief to the District.

Mode of working: Longwall; the working face is about a third of a mile long. The clay has to be blasted.

Treatment: The clay is weathered in dumps 6 ft. in thickness, water being sometimes thrown onto the clay to assist the breaking-down of the lumps. The grog used is burnt fireclay.

H. T. HICKMAN.

Lye, Stourbridge.

Works: About half-a-mile south-west of Lye Station (G.W.R.).

Mine: Shafts (Huddy Castle) near the works. Another pit at the works is now worked only for coal.

Maps: One-inch New Ser. Ordnance 167; Old Ser. Geological 62 S.W.; six-inch Worcestershire 4 S.W. and S.E.

Huddy Castle: Latitude $52^{\circ} 27' 6''$. Longitude $2^{\circ} 7' 15''$.

Geological formation: Middle Coal Measures.

The fireclays represented are: The Old Mine (not worked at present); No. 1 New Mine (not good); Nos. 2 and 3 New Mine (being worked); No. 4 New Mine (not workable); No. 5 New Mine (very good and now being worked).

The quality of the No. 5 New Mine Clay is uniform throughout; the colour is mostly dark-grey, but some is black.

The beds dip N.W. at 45° .

Reserves: Underground these are large; on the surface there is an ample supply.

Mode of working: The clays are worked on the pillar-and-stall system. There are two shafts, the deeper one being used for de-watering the workings. Water is a source of trouble at Huddy Castle, but there it can be kept down by the existing pumps; at the Lye pit the clay is drowned out and only coal is worked.

Treatment: The clay is weathered on the banks for as long a period as circumstances permit, up to three years. Cannocks are mostly rejected underground, but such as come to the surface are exposed by the weathering and are removed by hand.

KING BROTHERS (STOURBRIDGE), LTD.

Netherend, Stourbridge.

Works: (1) Principal works at Netherend; (2) a smaller works at the Thorns, $\frac{1}{4}$ mile north of Lye Station (G.W.R.).

Mines: (1) Shafts (Netherend Colliery) at the Netherend Works.

(2) Shafts (Cradley Park Colliery) between Lye and Cradley.

(3) Shafts (Nos. 3 and 4, 11 and 12 Pits, Delph Colliery), one-third mile north-east of Lye Station.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.

Netherend Colliery: six-inch Worcestershire 4 S.E.

Latitude $52^{\circ} 27' 36''$. Longitude $2^{\circ} 5' 45''$.

Cradley Park Colliery: six-inch Worcestershire 4 S.E.

Latitude $52^{\circ} 27' 21''$. Longitude $2^{\circ} 5' 38''$.

Delph Pits: six-inch Staffordshire 71 S.E.

Latitude $52^{\circ} 27' 50''$. Longitude $2^{\circ} 6' 35''$.

The Delph Nos. 3 and 4 Pits are a few yards north-west of Nos. 11 and 12.

Geological formation: Middle Coal Measures.

At Netherend the No. 1 New Mine Fireclay is raised; at Cradley Park and at the Delph Pits the Old Mine Fireclay is raised.

At Netherend the Old Mine Clay was 149 yds. 1 ft. 4 in. deep; the New Mine Clay, 167 yds. 9 in. deep, is overlain by the New Mine Coal, an inferior seam 10 or 11 in. thick. (Plate II, No. 3.)

At Cradley Park the Old Mine Clay, which averages 2 ft. 3 in. in thickness, is 186 yds. 2 ft. deep. (Plate II), No. 4.)

At the Delph Pits it varies from 2 ft. 6 in. to 2 ft. 8 in. thick, and is 24 yards deep. The New Mine Clay has not yet been reached.

In addition to the fireclays, the Brooch and Thick Coals are worked. The Old Mine Clay has a top layer, 5 in. to 8 in. thick, of dark clay of a mild nature. This is not of much value, and is not used unless it comes down with the rest. The bottom part of the seam, especially the lowest 15 or 18 in., is the strongest.

Reserves: Ample. The working of fireclay at Cradley Park Colliery has been carried on for about 3 years only, and it is estimated that the reserves underground will last 50 years. At the Delph Pits the New Mine Clay has not yet been touched.

The underground water is the chief obstacle to a large output. This can be dealt with at the pits now working, but in the Cradley district the water is rising.

Mode of working: Pillar-and-stall.

Treatment: The clays are weathered as long as possible—at least two or three months. The stronger clays need the longer weathering. The Old Mine Clay is selected into 'best,' from which glass-house pots and tank-blocks are made; 'seconds,' and 'thirds' or 'offals,' from which ordinary firebricks are made. This grading into qualities, which is done at the dumps by women, depends on the nature of the clay, and not on its position in the seam. The grogs used are burnt fireclay and waste firebrick. For special purposes Gornal Stone, Cambrian quartzite from the Lickey Hills near Bromsgrove, and quartzite from North Wales have been used.

EVERS & SONS (E. J. & J. PEARSON).

Homer Hill.

Works: Homer Hill Works, Netherend, Cradley.

Mine: Shafts (Homer Hill Colliery), adjacent to the works.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Worcestershire 4 S.E.

Latitude 52° 27' 54". Longitude 2° 5' 27".

Geological formation: Middle Coal Measures.

The following is the section of the shaft (Plate II, No. 5):—

	Thickness.		Depth.	
	Ft.	In.	Yds.	Ft. In.
Measures	294	3	98	0 3
Two-foot Coal	1	1	98	1 4
Fireclay and bats	15	3	103	1 7
Brooch Coal	2	2	104	0 9
Clod, stone and bats	5	3	106	0 0
One-foot Coal	1	3	106	1 3
Strong rock and black ground	16	9	112	0 0
Strong binds and peldon	80	9	138	2 9
Cat earth or 'heath'	3	0	139	2 9
Black bat	2	0	140	1 9

						Thickness.	Depth.		
						Ft. In.	Yds.	Ft.	In.
Thick Coal.	{	Spires and White Coal ...	...	...	...	8 0	—	—	—
		Tow Coal Bat ...	...	...	...	3 0	—	—	—
		Brazils and Tow Coal ...	...	...	...	5 0	—	—	—
		Fine coal parting... ..	...	...	...	0 5	—	—	—
		Veins and Fine Coal ...	...	...	...	6 0	—	—	—
		Stone Coal ...	...	...	...	2 6	—	—	—
		Patchells Bat ...	...	...	...	0 3	—	—	—
		„ Coal ...	...	...	...	2 3	—	—	—
		Sawyer Coal ...	...	...	...	1 8	—	—	—
		Slipper coal ...	...	...	...	3 2	—	—	—
		Benches ...	...	...	...	2 0	152	0	0
		Grains and Gubbin Measures ...	...	...	...	5 0	153	2	0
		Crank Bat ...	...	...	...	0 2	153	2	2
		Upper Heathen Coal ...	...	...	...	2 2	154	1	4
		Bastard fireclay mixed with balls ...	...	...	...	16 0	159	1	4
		Lower Heathen Coal ...	...	...	...	2 4	160	1	8
		Measures ...	...	...	...	12 9	164	2	5
		Broad Earth, top full of cannocks ...	...	...	...	10 9	168	1	2
		Bats and batty coal in places ...	...	...	...	4 6	169	2	8
		OLD MINE FIRECLAY (working) ...	...	...	...	3 6	171	0	2
		White rock ...	...	...	...	8 0	173	2	2
		Measures ...	...	...	...	32 3	184	1	5
		Bastard fireclay ...	...	...	...	1 6	187	0	11
		Bats ...	...	...	...	1 6	188	0	5
		NO. 1 NEW MINE FIRECLAY ...	...	...	...	3 0	189	0	5
		Measures ...	...	...	...	10 2	192	1	7

The total depth recorded was 203 yards, and a trial pit proved No. 2 New Mine Fireclay.

The Broad Earth is in places overlain by a stinking coal and in places overlies a thin coal-seam.

The No. 1 New Mine Fireclay, although not proved in the shaft, was found 50 yards away from it.

The ground is crossed by several faults running east-and-west with throws of about 24 ft. The beds dip generally S.S.E.

The Old Mine Fireclay is the only one being worked; it is milder than the No. 1 New Mine Fireclay, and decreases in strength downward.

Reserves: Underground there is an ample supply of the Old Mine Clay.

Mode of working: The fireclay is worked on the longwall system; the coal pillar-and-stall. Water is a serious trouble, but it can be coped with and kept below the Old Mine Clay level, with existing pumps.

Treatment: Weathering of the clay is allowed up to a period of 10 years.

MOBBERLEY & BAYLEY.

Cradley Heath.

GARRATT'S LTD.

New British Collieries, Old Hull, Staffs.

Works: At Toy's Green, Cradley.

Mine: Shafts (Timbertree Colliery) at Overend, Cradley.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Staffordshire 71 S.E.

Latitude $52^{\circ} 27' 53''$. Longitude $2^{\circ} 4' 12''$.

Geological formation: Middle Coal Measures.

The following is an abridged section of the measures in the deepest shaft (Plate II, No. 6):—

	Thickness.		Depth.		
	Ft.	In.	Yds.	Ft.	In.
Measures	735	0	245	0	0
Thick Coal with partings	32	5	255	2	5
Measures with Gubbin ironstone	6	0	257	2	5
Upper Heathen Coal	2	0	258	1	5
Measures	11	5	262	0	10
Coal,		6	262	1	4
Clod	2	5	263	0	9
Lower Heathen Coal	2	10	264	0	7
Measures	18	0	270	0	7
Stinking coal [? Sulphur Coal]	1	6	270	2	1
Slums and coal	5	10	272	1	11
Fireclay and coal mixed (useless)	3	0	273	1	11
Measures and slums	13	0	277	2	11
Rock and clod with ironstones	22	0	285	0	11
Slums	2	6	286	0	5
OLD MINE FIRECLAY	3	2	287	0	7
Rock	8	0	289	2	7

The beds dip a little east of south at from 1 in 15 to 1 in 12.

The quality of the Old Mine Fireclay is good; its texture is uniform, but it varies in colour from pale-grey to brown or black.

Reserves: These are on the tips only. Further development depends upon the unwatering of the mine.

Mode of working: The mine is situated on the south-eastern limit of the Netherton anticline and is just outside the area controlled by the Mines Drainage Scheme. Local pumps have stopped work and water has flooded the Timbertree Mine.

The clay is worked on the longwall system, and the coal by pillar-and-stall, both being followed up the dip. All waste is left below except a few cannocks, which are collected at the tips and rejected.

Treatment: The clay is left on the banks to weather for from one to two years before being made up at the works by the usual processes.

Brettell Lane and Delph Area.

HARRIS & PEARSON.

Brettell Lane, Stourbridge.

Works: (1) About 100 yards N.W. of Brettell Lane Station (G.W.R.), 1 mile N.N.E. of Stourbridge.

(2) At Amblecote, one-third mile S.S.E. of Brettell Lane Station.

Mines: (1) Shafts at Plant's Hollow (Amblecote), $\frac{1}{4}$ mile S. of Brettell Lane Station (G.W.R.).

(2) Shafts at Turner's Lane, Delph, about $\frac{1}{2}$ mile E.S.E. of Brettell Lane Station.

Maps: One-inch New Ser. Ordnance 167; Old Ser. Geological 62 S.W.; six-inch Staffordshire 71 N.W.

Plant's Hollow: Latitude $52^{\circ} 28' 13''$. Longitude $2^{\circ} 8' 11''$.
 Turner's Lane: Latitude $52^{\circ} 28' 16''$. Longitude $2^{\circ} 7' 20''$.

Geological formation: Middle Coal Measures. Old Mine Fireclay; Nos. 1 and 3 New Mine Fireclays.

In the Plant's Hollow shafts the bottom of the Old Mine Clay is 133 ft. deep, and that of the No. 1 New Mine Clay 188 ft., the clays being respectively 7 ft. and 4 ft. thick. A thin seam of fireclay a short distance below the Upper Heathen Coal, though once tried for glass-house pots, was found to be unsuitable; it has a high silica percentage. Other clays below the No. 1 New Mine Clay are: No. 2 New Mine, too thin to be worth getting; No. 3, which is working, and No. 4, which, though unimportant, has been worked occasionally.

The beds rise to the south at 1 in 13 ($4\frac{1}{2}^{\circ}$). The ground is separated from the Turner's Lane property by a fault ranging south-west and north-east, with a north-westward downthrow.

Reserves: At Plant's Hollow the reserves, which are ample for present requirements, are limited on the west by the boundary fault of the coalfield, and on the south-east by the fault mentioned above. Underground water is the chief impediment to a larger development.

At the Turner's Lane Shafts the Old Mine Clay has an average thickness of 5 ft. There are ample reserves and water gives no trouble.

Mode of working: Pillar-and-stall. Impurities such as iron-stone-nodules ('canks' or 'cannoeks') are picked out.

Treatment: The clays are weathered at least six months, and sometimes as much as three years. Any impurities, such as iron-stones, not left underground are picked out by hand as the clay is removed from the dumps to the grinding-mill. The grog used is ground firebrick; coarse Triassic sand from Wordsley, and Gornal Stone from the Coal Measures, are also used.

TROTTER, HAINES & CORBETT, LTD.

Brettell Lane, Stourbridge.

Works: At Brettell Lane, 1 mile N.N.E. of Stourbridge.

Mine: Shafts (Brettell Lane Colliery) about 100 yards E. of Brettell Lane Station (G.W.R.).

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Staffordshire 71 N.W.

Latitude $52^{\circ} 28' 26''$. Longitude $2^{\circ} 8' 1''$.

Geological formation: Middle Coal Measures. Nos. 1 and 2 New Mine Fireclays.

The No. 1 New Mine Clay, 4 ft. to 5 ft. thick, is 335 ft. deep; No. 2 New Mine Clay, 3 ft. thick, is 368 ft. deep. Beside these, other clays present in the property are: some Old Mine Clay and No. 4 New Mine Clay, which is untouched. (Plate I, No. 4.)

The measures dip N.W. at 1 in 25.

Reserves: Ample, both underground and in dumps on the surface.

Mode of working: Pillar-and-stall. Water presents the chief obstacle to the economical working of the mine, but it can be kept under by the present pumping arrangements. The property also benefits from the operations of a voluntary association for dealing with the water.

Treatment: The clay is weathered at least 12 months. Little selection of the clay is made; the No. 1 and No. 2 New Mine clays are tipped together on one dump. The grogs used are burnt fireclay, old firebricks, and for special orders sandstone from the Coal Measures of Gornal (Gornal Stone).

H. T. HICKMAN (E. J. & J. PEARSON).

Brettell Lane, Stourbridge.

Works: On northern bank of the Stourbridge Canal, 300 yards east of Brettell Lane Station (G.W.R.).

Mine: Shafts on southern bank of canal, opposite the works.

Maps: One-inch New Ser. Ordnance 167; Old Ser. Geological 62 S.W.; six-inch Staffordshire 71 N.W.

Latitude $52^{\circ} 28' 23''$. Longitude $2^{\circ} 7' 50''$.

Geological formation: Middle Coal Measures.

The shafts are only a few hundred yards from the Brettell Lane Colliery of Messrs. Trotter, Haines and Corbett (p. 131), and those at Tinker's Field belonging to Messrs. Bowen's Successors (below). According to Prof. W. S. Boulton¹ the following clays are present:—No. 1 New Mine: 'Strong White Clay, No. 2,' and 'Strong Roof Clay, No. 3,' separated by 11 ft. of measures, probably together representing No. 2 New Mine; 'New Mine Fireclay No. 4,' probably being No. 3 New Mine; and 'New Mine Fireclay No. 5,' perhaps being the equivalent of No. 4 New Mine.

The pits are closed for the present, the raw materials for the works being supplied from some of Messrs. Pearson's other pits (pp. 128, 134).

Reserves: The underground reserves extend southward.

BOWEN'S SUCCESSORS, LTD.

Brettell Lane, Stourbridge.

Works: Clattershall Works, 100 yards S.E. of Brettell Lane Station (G.W.R.).

Mine: Shafts at Tinker's Field, $\frac{1}{4}$ mile E.S.E. of Brettell Lane Station.

Maps: One-inch New Ser. Ordnance 167; Old Ser. Geological 62 S.W.; six-inch Staffordshire 71 N.W.

Latitude $52^{\circ} 28' 19''$. Longitude $2^{\circ} 7' 47''$.

Geological formation: Middle Coal Measures. Old Mine Fireclay; Nos. 1, 2 and 3 New Mine Fireclays.

¹ *Trans. Ceramic Soc.*, vol. xvi (1916-17), p. 237, 1917.

Reserves: Ample. Water is the chief obstacle to the economical working of the mine, and the need of a co-operative scheme for dealing with the problem is strongly felt.

Method of working: Pillar-and-stall.

Treatment: The clays are dumped together in one heap and are not selected. Weathering lasts at least two, sometimes three years. The grog used is waste firebricks, and for special requirements, Gornal Stone is added.

GEORGE K. HARRISON, LTD.

Lye, Stourbridge.

Works: (1) On the north side of the Great Western Railway at Lye Station.

(2) On south side of the Stourbridge-Dudley road, 300 yards S.W. of Brettell Lane Station (G.W.R.).

(3) At Nagersfield, between Brettell Lane and Buckpool.

Mines: (1) Shafts about 300 yards N.W. of Lye Station, and close to the Lye Works.

(2) Shafts at the Brettell Lane Works.

(3) Shafts at the Nagersfield Works.

Maps: One-inch New Ser. Ordnance 167; Old Ser. Geological 62 S.W.

Lye: Six-inch Worcestershire 4 S.E.

Latitude $52^{\circ} 27' 49''$. Longitude $2^{\circ} 7' 8''$.

Brettell Lane: Six-inch Staffordshire 71 N.W.

Latitude $52^{\circ} 28' 23''$. Longitude $2^{\circ} 8' 23''$.

Nagersfield: Six-inch Staffordshire 71 N.W.

Latitude $52^{\circ} 28' 34''$. Longitude $2^{\circ} 8' 44''$.

Geological formation: Middle Coal Measures. Old Mine Fireclay; Nos. 1 and 2 New Mine Fireclays.

At Lye the Old Mine Clay is being worked, and the Nos. 1 and 2 New Mine clays have been proved. At Brettell Lane and Nagersfield the Old Mine Clay and Nos. 1 and 2 New Mine clays are being worked.

The Old Mine Clay, which is 5 to 8 ft. thick, is suitable for glass-house pots and highly refractory goods. The No. 1 New Mine Clay at Nagersfield is about equal to it in quality; No. 2 is suitable for ordinary firebrick goods. Under the Brooch Coal at Nagersfield and Brettell Lane there is a good clay containing 66 per cent. of silica. The Four-Foot Earth under the Upper Heathen Coal has been worked at Nagersfield and Lye. The Bottom Rock under the Lower Heathen Coal has been worked at Lye, and was found to be of high quality. A highly siliceous clay, called the 'blazer,' at the top of the Old Mine Clay is used for a special 'silica firebrick.'

Reserves: Ample, both underground and on the surface. At Brettell Lane there are reserves of Old Mine Clay still unworked, and at Nagersfield the No. 2 New Mine Clay has not been as yet much drawn upon. At Lye the Old Mine Clay is approaching exhaustion; No. 3 New Mine is worked out; but Nos. 1 and 2 are not yet working.

The Nagersfield and Brettell Lane properties are bounded on the west by the boundary-fault of the coalfield. At Lye the measures are shallow, rise to the south-east, and soon crop out.

Water involves heavy pumping expenses, and at Lye the difficulties are so serious that a statutory scheme for underground drainage is becoming an urgent necessity if the mines are to remain in operation.

Method of working: Longwall retreating.

Treatment: The clays are weathered at least 9 months, and in favourable circumstances for 3 years or more. To assist the weathering the dumps are sprayed with water. The Old Mine Clay needs the longest weathering. The grogs used are burnt fireclay, and waste firebrick; Gornal Stone is added for certain purposes.

E. J. & J. PEARSON, LTD.

Stourbridge.

Works: (1) Delph Works, $\frac{1}{4}$ mile south of St. Michael's Church, Brierley Hill.

(2) Crown Works, Amblecote, $\frac{1}{2}$ mile south-west of the Delph Works.

(3) Tintam Abbey Works, Lye; $\frac{1}{3}$ mile north of Lye Station (G.W.R.).

In addition the works and mines of Messrs. S. Evers & Sons, Ltd., Homer Hill, Cradley, and those of Mr. H. T. Hickman at Brettell Lane, have lately been taken over by Messrs. Pearson (p. 132).

Mines: (1) Shafts known as Delph No. 7 Pit adjacent to the Delph Works (Plate I, No. 3).

(2) Shaft known as Iron Jack Pit, on south side of the canal, about 300 yards west of the Delph Works.

(3) Shafts called Crown No. 5 Pit, on south side of a brook, 500 yards south-west of the Delph Works (Plate I., No. 2).

(4) A windlass-pit called New Ravensitch, 220 yards south-east of Ravensitch, $\frac{1}{2}$ mile S. of the Delph Works.

(5) A windlass-pit and drift on the Freehold Farm, $\frac{3}{8}$ mile N.N.E. of Stambermill Church.

Maps: One-inch New Ser. Ordnance 167; Old Ser. Geological 62 S.W.

		<i>Latitude.</i>	<i>Longitude.</i>
(1) Six-inch Staffs.	71 N.W.	52° 28' 26".	2° 7' 16".
(2) Six-inch Staffs.	71 N.W.	52° 28' 25".	2° 7' 36".
(3) Six-inch Staffs.	71 N.W.	52° 28' 18".	2° 7' 43".
(4) Six-inch Staffs.	71 S.W.	52° 27' 53".	2° 7' 20".
(5) Six-inch Staffs.	71 S.W.	52° 27' 46".	2° 7' 17".

Geological formation: Middle Coal Measures.

At No. 7 Delph Pit, the Broad Earth, 2 ft. thick, and the Old Mine Clay, 4 ft. thick, are being raised. Beside these clays, 2 ft. of the Four-Foot Earth (which is here 4 ft. thick) are workable.

The Old Mine Clay presents the following details:—

	ft.	In
Broad Earth, merging downward into black mild clay, (0 to 15 in. thick)	2-3	0
Silica-rock suitable for siliceous firebricks	0	3-4
Old Mine Clay of ordinary type	4	0

At the Iron Jack Pit the Four-Foot Earth is raised for sale to the North Staffordshire potteries, where, after the iron is extracted by a magnetic process, the clay is utilized. At the Crown No. 5 Pit the Old Mine Clay, 6 ft. thick, and No. 1 New Mine, 5 ft. thick, are working. The No. 2 New Mine is not profitable, the No. 3 New Mine has been proved only. At the New Ravensitch pit the Old Mine Clay is being worked and is of very good quality. At the Freehold pit, the Bottom Rock, 3 ft. thick, is being raised; the Broad Earth, $3\frac{1}{2}$ to 4 ft. thick, the Old Mine Clay, $4\frac{1}{2}$ ft., and Nos. 1, 2 and 3 New Mine clays have been proved.

Reserves: These are ample for many years' requirements. Here again water presents grave difficulties.

Method of working: Pillar-and-stall. Most of the clays require blasting.

Treatment: The clays, tipped in separate dumps, are weathered for about 12 months.

With such a range of clays, considerable selection and blending for the various requirements of customers can be practised. For instance, a black clay, in places 15 in. thick, that closely overlies the Old Mine Clay and is the mildest of all the clays, is specially selected for glass-house pots. A siliceous rock, 3 to 4 in. thick, immediately above the Old Mine Clay, is useful for a brick required to resist penetration by gases, as the brick acquires a superficial glaze. A rock forming the roof of the No. 1 New Mine Clay is a coarse siliceous grit, 7 to 8 ft. thick, of which about 5 ft. is of good quality. This could perhaps be used as a siliceous grog. The only grog used is burnt fireclay.

Brierley Hill and Dudley Area.

DOULTON & Co., LTD.

Springfield, Dudley.

Saltwells Quarry and Day-slants.

Works: At Rowley Regis.

Quarry and Slants: Situated about 1 mile E. of Brierley Hill.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Staffordshire 71 N.E.

Latitude $52^{\circ} 28' 55''$. Longitude $2^{\circ} 5' 40''$.

Geological formation: Middle Coal Measures.

Some of the clays worked at this quarry are occasionally made into firebricks, but the greater part is used for sanitary ware, etc. Coal also is raised.

Below is a rough section¹ of the beds from estimates made by the Manager.

¹ See also Prof. W. S. Boulton, 'The Clays of South Staffordshire and its Borders.' *Trans. Ceramic Soc.*, vol. xvi (1916-17), p. 237, and Fig. 4, 1917.

							Thickness.
							Ft. In.
BROOCH FIRECLAY ...	...	...	...	...	...	...	6 6
{ Coal ...	...	...	...	...	...	...	1 0
Brooch Coal { Shaly bat ...	...	...	...	...	...	...	5 6
{ Coal ...	...	...	...	...	...	...	2 0
Measures with '10-ft. Clays'	...	...	...	...	...	...	225 0
Thick Coal (worked out or burnt out)	...	...	...	...	...	...	—
Gubbin measures ...	...	...	...	...	...	...	6 0
Upper Heathen Coal ...	...	...	...	...	...	...	—
Upper Heathen Clay ...	...	...	...	...	...	...	—
Measures ...	...	...	...	...	...	...	15 0
Lower Heathen Coal ...	...	...	...	...	...	...	—
Lower Heathen Clay ...	...	...	...	...	...	...	—
White stone ...	...	...	...	...	...	...	—
Old Mine Clay ...	...	...	...	...	...	...	—
Thin coal ...	...	...	...	...	...	...	—
'23-ft. Clays' (= New Mine Fireclays, Nos. 1-7)	...	...	...	...	...	...	—

The Brooch Clay is won from an open working and two slants situated some distance east of the main quarry in which the lower beds are exposed. In plan, this quarry is oval and is divided into S.E. and N.W. parts by a 40 ft. fault, down north-east. The N.W. part is traversed by a 15-ft. fault, down south, that springs from the 40-ft. fault.

In the S.E. part of the pit the clays, from the Old Mine up to, and including, those above the Thick Coal, are visible in section, whilst in the northern wall of the pit (N. of the 15-ft. fault) the 23-ft. or New Mine clays are exposed beneath a thin coal. They also, presumably, occupy the ground between the two faults on the western side of the pit.

The burnt-out or worked bed of Thick Coal dips between E.S.E. and S.E. at 1 in 4 (13°), and the Brooch Clay has a similar inclination.

The clays vary in character and are put to different uses. The Brooch Clay varies from a brownish mild type, useful for sanitary ware, to a less useful pale sandy type, whilst the 10-ft. Clays are 'tight' clays suitable for drain-pipes and stone bottles. The Heathen Clays are of little use, but the White Stone and Old Mine Clay are occasionally employed for making firebricks. For the latter purpose also the 23-ft. or New Mine clays are suitable, but they are more usually made up into white glazed goods.

Reserves: There are ample reserves of clay suitable for refractory ware, in addition to those more fitted for other purposes.

Mode of treatment: The clays are weathered as long as possible.

STOURBRIDGE GLAZED BRICK & FIRECLAY CO., LTD.

Holly Hall, Dudley.

Thornleigh, Samson and Cabbage Hall Pits, Holly Hall Brickworks, and Corbyn's Hall Brickworks.

Mine: Shafts (Thornleigh Colliery), situated about $\frac{3}{4}$ mile E. of Holly Hall.

Beside Thornleigh Pit Nos. 1 and 2 shafts, the company controls the neighbouring Samson and Cabbage Hall Pits, both of these being temporarily closed. A second brickworks, situated

at Corbyn's Hall, Pensnett, about a mile south of Barrow Hill, is also closed temporarily. The pit at Corbyn's Hall was flooded by water in 1914.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Worcestershire 1 S.E.

Thornleigh: Latitude $52^{\circ} 30' 4''$. Longitude $2^{\circ} 5' 32''$.

Geological formation: Middle Coal Measures.

The following section of one of the shafts (deepened in 1910) gives details of the beds below the Thick Coal:—

Thornleigh No. 2 Pit.

	Ft.	In.
Measures with Brooch Coal	267	6
Thick Coal (mostly worked out)	30	0
Gubbin and Grains Measures, with Top Heathen Coal ...	15	0
Bottom Heathen Coal	3	6
Blue shale to bottom of White Ironstone	18	0
Measures with Pennystone Ironstone	15	0
Coal, 2 ft.		
Clod, 9 in.		
Coal, 1 ft. 6 in.		
Brown bat, 2 ft. 6 in.		
Little Coal, 1 ft.		
New Mine Coal		7 9
NEW MINE FIRECLAY (for glazed bricks)	2	6
White Sand Rock	12	0
GLAZED-BRICK CLAY	3	2
Black clunch	1	1
Fireclay Coal	1	11
Strong batty ground	2	0
GOOD FIRECLAY (the chief seam mined)	10	5
Coal	1	9
(The beds below this depth are proved but not worked.)		
Shaly clay	0	6
MILD FIRECLAY (very good)	5	1
Dark shaly clay	0	7
STRONG STRATIFIED FIRECLAY (good)	6	8
Fireclay (with few stones in top; lower part fat and bright)...	6	7
Fireclay and ironstone-nodules	2	7
Black shale with coal-streaks	3	3
Coal	2	0
Fireclay and blue ground, mixed with ironstones	3	0
Fireclay	3	7
Coal, 1 ft. 8 in.		
Black bat 6 in.		
Fireclay (brown shaly), 2 ft. 4 in.		
Coal, 7 in.		
Black musky ground, 1 ft. 6 in.		
Bottom coal and fireclay... ..		6 7
Strong fireclay, rocky	6	4
Binds and bats	3	6
Coal (stinking) and bats (bottom of shaft)	1	6
Fireclay	5	0
Binds... ..	2	0
Fireclay	8	0
Limestone (supposed) at bottom of boring	1	6

At Thornleigh Pit the beds are nearly horizontal but rise southward towards the Netherton anticline, in which direction the New Mine Coal is now being worked. To the north the Russell's Hall Fault, with a downthrow south of 60 yards, forms a limit to the beds; to the south they run out at the surface.

The Thick Coal has been previously worked in all three mines, and is now being worked for the third time in Samson Mine.

At Cabbage Hall the Brooch Coal lies at 50-60 yards depth.

The Brooch Clay is an aluminous pot-clay, suitable for sanitary and stone-ware, stone bottles, etc., whilst the New Mine fireclay is suitable for glazed bricks. The underlying White Sand Rock is local to the shaft; farther away it passes into 3 ft. of sand-rock on 9 ft. of clay, used for glazed bricks. Lower down the strong batty ground is also local; elsewhere it is a brick clay.

The 'good' fireclay is the best in the mine, and claimed to be nearly equal in quality to the Old Mine Fireclay. At the top it is usually light-brown in tint, whilst below it is paler; it varies, however, by increase in sandiness from point to point. Occasionally a patch as much as 100 yards in length must be left unworked owing to this kind of deterioration, which is also marked in the White Sand Rock and clay mentioned above. The top 3-4 ft. of the 'good' clay is used chiefly for making firebricks, the lower part for glazed bricks. It is a strong clay throughout. Some of the above clays contain large balls of ironstone.

Samples of the lower clays proved in the shaft have been kept for reference, and some have yielded satisfactory bricks on trial.

The mild fireclay is claimed to be very good, and the strong stratified fireclay is also good. The rocky fireclay has been tested and makes a good glazed brick.

Reserves: Below ground there is an ample reserve of clay, but surface-dumps are now small.

Mode of working: The mines are worked pillar-and-stall.

At Thornleigh clay is raised, in normal times, at one shaft, and coal at the other. Water gives trouble in wet seasons by entering the clay-workings from the Thick Coal gob above. At such times 4,000 tons a day are pumped out. Balls of ironstone are brought to the surface and sold to local ironworks as low-grade ore (25 per cent. Fe).

Treatment: Long-continued weathering is desirable.

Kingswinford, Himley and Pensnett Area.

THE HIMLEY FIRE & RED BRICK CO., LTD.

Kingswinford, near Dudley.

Stourbridge Extension Works.

Works: About $\frac{3}{4}$ mile north-east of St. Mary's Church, Kingswinford.

Mine: Shafts at the works.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Staffordshire 67 S.W.

Latitude $52^{\circ} 30' 36''$. Longitude $2^{\circ} 8' 50''$.

Geological formation: Middle Coal Measures. New Mine Fireclay.

The New Mine Fireclay, 4 ft. thick, lies at a depth of 170 yds. 2 ft. The measures are practically flat.

Reserves: Ample.

Mode of working: Longwall.

Treatment: Weathered as long as possible—at least six months. There is no selection of the clay, though this varies a little in composition both laterally and vertically. All varieties are ground together. The grog used is waste firebrick; red Bunter sands from Kingswinford also are introduced.

J. T. PRICE & Co., LTD.

Kingswinford, near Dudley.

Works: Called Kingswinford Works, on south side of Dudley road $\frac{1}{4}$ mile east of Kingswinford Church.

Mines: Clay is bought mainly from (1) the Earl of Dudley's Himley Colliery (No. 7 Pit), and partly from (2) Messrs. H. S. Pitt & Co.'s Shut End Colliery, both near the works.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Staffordshire 67 S.W.

Himley No. 7 Pit: Latitude $52^{\circ} 30' 45''$. Longitude $2^{\circ} 9' 45''$.

Shut End Colliery: Latitude $52^{\circ} 30' 27''$. Longitude $2^{\circ} 8' 30''$.

Geological formation: Middle Coal Measures. Fireclay called the Himley Fireclay.

At Himley No. 7 Pit the fireclay, which is 4 ft. thick, is said to be 155 yards deep, and underlies a coal next below the White Ironstone. It is probably the underclay of the New Mine Coal.

At Shut End Colliery several pits are yielding fireclay. At the No. 1 Pit the clay being worked as the New Mine Clay underlies a thin coal, and is about 4 ft. 6 in. thick.

The Himley Fireclay contains an average percentage of silica 63, alumina 32.

Reserves: Ample, both underground and in dumps.

Mode of Working: Pillar-and-stall.

Treatment: The clay is weathered at the works for about 18 months, and never (if it can be avoided) less than 9 months. The ironstone nodules are picked out as the clay is removed from the dumps to the grinding-mill. Different qualities of clay are selected and blended according to requirements.

The grogs used are waste firebrick and burnt fireclay: Gornal Stone, and Triassic and Glacial sands from Wall Heath near Kingswinford, also are employed.

JOHN WALKER.

Kingswinford, near Dudley.

The Oak Farm Fireclay and Firebrick Works.

Works: At Oak Farm, $\frac{3}{4}$ mile N.N.E. of St. Mary's Church, Kingswinford.

Mine: Shafts (No. 9 Pit, Oak Farm Colliery), 100 yards west of the works.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Staffordshire 67 S.W.

Latitude $52^{\circ} 30' 43''$. Longitude $2^{\circ} 9' 9''$

Geological formation: Middle Coal Measures. New Mine Fireclay.

The section of the clay and associated measures is as follows (Plate I, No. 6):—

	Thickness.			Depth.		
	Ft.	In.		Yds.	Ft.	In.
White Ironstone	5	6	...	163	2	9
Measures	39	0	...	176	2	9
New Mine Coal (working)	1	8	...	177	1	5
NEW MINE FIRECLAY (working)	3	0	...	178	1	5
Measures	16	9	...	184	0	2
Fireclay (canky)	3	10	...	185	1	0

The new Mine Clay in places increases in thickness to 6 ft. The measures dip S.W. at angles varying from 1 in 12 to 1 in 15.

Reserves: A 60-yard fault with westward downthrow, known as the Shut End Fault, bounds the property to the eastward. To the west the Coal Measures are cut off against the Trias by the western boundary-fault of the coalfield.

No clay has been raised recently owing to water troubles, but there is a large stock of clay on the surface sufficient for several years' requirements. The property falls within the Kingswinford area under the South Staffordshire Mines Drainage scheme, and one penny per ton is levied on all minerals raised; but this pays only for surface-drainage.

Mode of working: Longwall.

Treatment: The clay is weathered for 3 years when possible. Any ironstone-nodules not left underground are picked out at the dumps by girls. The bottom part of the clay is mildest, though the whole band is described as a strong clay. The whole of the clay is ground together, no selection being made.

The grogs used are burnt fireclay and waste firebrick; red Triassic sand from Kingswinford and Gornal stone are added in some cases.

STOURBRIDGE REFRACTORIES CO.

H. S. PITT & Co.

Shut End Colliery.

Pensnett, near Dudley.

Shut End Colliery and Brickworks.

Situation: Works and three shafts are situated close together about 1 mile N.E. of Kingswinford Church.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Staffordshire 67 S.W.

Latitude 52° 30' 25". Longitude 2° 8' 30".

Geological formation: Middle Coal Measures.

Three pits of the Shut End Colliery, Nos. 1 and 9 and the Dandy Pit, provide the necessary clay.

The chief beds traversed by No. 1 pit-shaft are as follows:—

Brooch Coal.	White or New Mine Ironstone.
Flying Reed.	Old Mine Clay (useless).
Thick Coal.	New Mine Coal (very thin).
Gubbin Ironstone.	NEW MINE FIRECLAY (worked) to
Heathen Coal.	95 yds. depth.

Pit Bottom at 103 yds. depth.

At No. 9 pit-shaft, situated about 150 yards S.S.E. of No. 1, the base of the New Mine Clay, which is the seam worked, lies at 117 yards, and the shaft-bottom at 120 yards. The three pits appear to lie within the angle formed by a large N.-S. fault (said to be 80 yards down west, although shown on the geological map as 60 yards), and a nearly W.S.W.-E.N.E. fault (35 yards down south). The N.-S. fault cuts the Shut End Colliery into two parts, there being 20 shafts on the east and 10 on the west. The coals in the three shafts under consideration have all been worked from time to time.

The New Mine fireclay has an average thickness of 4 ft. 6 in., but varies from point to point in both tint and uniformity, and occasionally contains cannocks.

Reserves: Reserves are said to be good for many years. Some of the higher clays in the pits could be used for common brick or stoneware pottery.

Mode of working: All the clay is worked longwall. Water is chiefly dealt with at a coal-pit situated a short distance south of the Dandy Pit. The clay is hauled by electric power to the works, where it is handled in the raw state, although weathering is said to improve it.

Treatment: The works are modelled on a German pattern, similar to brickworks situated in the district S. and S.E. of Dresden, where fireclay-works are clustered together in the forests, and are frequently buildings of four storeys with electric-power installation. The type is sufficiently new to the firebrick industry in this country to be worth special description.

At the Stourbridge Refractories Company, the works consist of one large building in which the mills, kilns and drying-floors, etc., are all beneath one roof. One part of the building is occupied by the electrically-driven mills, the other part is divided into a ground floor with the kilns, and an upper floor where the bricks are made and dried.

The clay is brought by trolley to a shed above the dump, and the cannocks are picked out. It is then tipped and mixed with the requisite amount of grog, Gornal Stone or Welsh silica-stone, and run in trucks to the mills, where it is ground under edge-runners in a rotating pan. A second pan is used for making fire-clay cement. From the pan the brick clay is hoisted to a large tempering-pan, and descends thence to a pug-mill. From this it is wheeled in trucks to an electric elevator, and raised to the upper floor, where it is made by hand into bricks, retorts, etc., and dried by waste kiln-heat, which is under control.

On the ground floor the kilns are grouped on the two sides of the building in series of 8 (16 in all), with a space between the two rows. The kilns are rectangular and said to hold from 20,000 to 24,000 bricks (9 in. by $4\frac{1}{4}$ in. by 3 in.) The flues are all connected with a single tall chimney-stack, and the kilns are fired, quite independently and in any convenient order, from four ports, two at each end of a kiln (semi-gaseous firing).

The heat of any one kiln can thus be utilised to dry the bricks stacked ready for firing in the next kiln, whilst the conserved

heat of the whole set is such that the bricks, after firing, are thoroughly annealed during cooling.

This practice may be compared and contrasted with that employed at Bracknell (Berks.), and other places, for making ordinary red brick by continuous firing; in which also the heat from the kilns is utilised for the drying-floors situated above them.

Most of the bricks are hand-made, their total shrinkage being about 1 in. per linear foot. In future a certain proportion of firebricks will be made by machinery. Firing is tested by seeger cones made at Stoke-on-Trent.

Gornal Area.

B. GIBBONS, JUNR., LTD.

Lower Gornal, Dudley.

Dibdale Works.

Works: At Dibdale, $1\frac{1}{2}$ miles N.W. of Dudley.

Mine: Shafts (Dibdale No. 2 or Cuba Pit), 400 yards S. of the works.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Staffordshire 67 S.E.

Latitude $52^{\circ} 30' 57''$. Longitude $2^{\circ} 6' 53''$.

Geological formation: Middle Coal Measures. Fireclays in and below the New Mine Coal, and in the Bottom Coal. (Plate I, No. 7.)

The section of the New Mine Coal is as follows:—

										Thickness.
										Ft. In.
Bats, depth 116 ft. 1 in.										—
New Mine Coal.	{	Coal	{	(working)	{	....	....	....	....	1 4
		Parting				....	....	....	....	—
	{	Coal				....	....	....	....	0 7
		Bats and fireclay				....	....	....	....	1 8
		FIRECLAY called the WASTE CLAY (working)				....	....	....	....	3 4
{	Bats	....	....	....	....	....	1 1			
	Coal (working)	....	....	....	....	....	1 9			
FIRECLAY called the TOP CLAY (working), depth 131 ft. 4 in.										5 6

Below these beds the section is continued as follows:—

										Thickn ss.
										ft. In.
Blue binds, white rock, black bat, grey fireclay rock										... 12 3
Bats										... 0 5
[? Fireclay	{	Coal (workable)	...	...	...	...	...	...	...	2 0
Coal.]		Fireclay (workable)	...	...	...	...	...	...	...	1 0
Strong white rock										... 10 4
[? Bottom	{	Coal (working)	...	...	...	...	...	...	...	1 10
		Slums and bat	...	...	...	...	...	...	...	1 6
		Coal.]	FIRECLAY (working)	...	...	...	...	...	...	2 4
		Coal and bat (working)	...	...	...	...	...	...	1 6	
Fireclay (workable)										... 1 11
Batty coal										... 0 6
Fireclay called the Bottom Fireclay (workable), depth 171 ft. 7 in.										4 8

The Top Clay at 131 ft. 4 in., being more uniform in quality than the other seams, is regarded as the best of the seams.

The Old Mine Fireclay is not present as a workable seam, but is supposed to be represented by a bed of grey rock, $6\frac{1}{2}$ ft. thick, at a depth of 99 ft. 2 in.

The measures lie in the form of a syncline or basin, the axis of which runs N.N.E. and S.S.W. The syncline is truncated on the S.S.W. by the Russell's Hall Fault, a downthrow of 120 ft. to the south-west.

Reserves: These are ample for present requirements, and the property contains clays estimated to be sufficient for another 30 years.

Method of working: Longwall system. Water can be kept under by continuous pumping. To deal with the heavy water during the winter a new compressed-air pumping plant has recently been installed.

Treatment: The clays are weathered at least two or three months, but it is recognised that a longer period would be an advantage. Most of the detrimental matter is left underground; any that comes up with the clay is picked out at the dumps.

The grogs used are waste fire-bricks, and rough firebricks specially made and burnt for the purpose. Gornal Stone is used for certain goods to counteract shrinkage.

JOHN WATERFIELD & SON.

Upper Gornal, Dudley.

Upper Gornal Works and Pit.

Location: At Upper Gornal, about $\frac{1}{2}$ mile N.W. of the Work-house.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Staffordshire 67 S.E.

Latitude $52^{\circ} 31' 23''$. Longitude $2^{\circ} 6' 42''$.

Geological formation: Middle Coal Measures.

The pit-shaft is 50 yards in depth, and the geological section is similar to that at the Cuba Pit (B. Gibbons Junr., Ltd., p. 142), Lower Gornal, with the exception that the highest beds are out, and some of the lowest are not proved. The chief seams are:—

Bottom Heathen Coal (at surface).	Coal and fireclay.
Sulphur (Stinking) Coal.	Coal with some fireclay (supposed
Grey rock (level of Old Mine Clay).	Fireclay Coal).
New Mine Coal.	FIRECLAY (2 ft.).
NEW MINE FIRECLAY ('WASTE' CLAY,	Batty coal.
18 in.).	BOTTOM FIRECLAY (5 ft.).
TOP FIRECLAY (3 ft. 6 in.).	

The Sulphur Coal is worked out, and the grey rock is almost gone. All the fireclays, except that in and above the supposed Fireclay Coal, are worked. As much coal as possible is raised.

The dip of the beds in the property is chiefly towards the south, and there are no faults worth mentioning.

The Bottom Fireclay, which in an adjacent property is said to contain half-a-yard of rock in the middle of the seam, is near

its outcrop, and is a mild workable clay in this property. All the clay-seams vary from grey to black in tint, the tops of the seams being usually dark and mild.

Reserves: As regards reserves, the workings are limited on the north by outcrop; the Bottom Fireclay, for example, which occurs at 45 yards depth in the shaft, crops out about 100 yards to the north. To the east and west also the clays rise towards the surface, in conformation with the structure of the Dibdale coal-basin. The workings of the Cuba Pit form the southern boundary.

Mode of working: The beds are worked both up and down dip, chiefly from levels following the strike. Surface-water enters near the outcrop, and drains away in the direction of Cuba Pit.

Treatment: Weathering is considered necessary, chiefly to give plasticity and to avoid a high shrinkage. The raw clay, even when milled, is said to be too dry to bind well. The grog used consists of burnt clay or brick, and Gornal Stone also is added.

Tipton, Coseley and Ettingshall Area.

J. & S. BAGGOTT.

Tipton.

Hurst Brickworks and Coneygree Pit.

Works: Situated in Tipton.

Mine: Shaft on south side of canal, Tipton Green.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Staffordshire 67 S.E.

Coneygree Pit: Latitude (approximate) $52^{\circ} 31' 26''$. Longitude (approximate) $2^{\circ} 4' 20''$.

Geological formation: Middle Coal Measures.

The shaft is from 60-70 yards in depth, and passes through measures from above the Thick Coal to the Fireclay Coal and its fireclay (see Plate I for an adjacent shaft-section).

The Fireclay Coal, which is nearly worked out, averages 2 ft. 6 in. in thickness, whilst the underlying clay varies in thickness from 1 ft. 6 in. to 3 ft. 6 in. The beds dip from E. to N.E. at about 7° .

Some faults, with a northerly downthrow, are said to occur on the south side of the property.

The clay has a thin dark top, the remainder being grey-brown and sometimes cannocky.

Reserves: Extension of the workings is curtailed by the location of inhabited buildings in the neighbourhood. Reserves are therefore short. Water has given little trouble in this mine to date. The firm's old Tipton Pieces Pit, about $\frac{1}{2}$ mile to the S.E. of this pit, was drowned out about 1914.

Treatment: The clay is preferred weathered, but is now used almost raw, owing to shortage and lack of surface-reserves.

G. G. WILKINSON & Co., LTD.

Tipton.

Foxyards Brick Works and Morgan's and Tomlinson's Pits.

Works: Situated about $\frac{1}{4}$ mile N.W. of Tipton Station (G.W.R.).

Mines: Clay is supplied to the works from local pits, such as (1) Elwell's Shaft, Bonn's Lane, near Tipton Hospital; (2) Morgan's Slant, at Swan Village, about $\frac{3}{4}$ mile N.W. of Tipton Station (G.W.R.), and (3) Tomlinson's Slant, about $\frac{1}{4}$ mile S.W. of Swan Village.

Details of the two latter are given below.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Staffordshire 67 N.E.

Geological formation: Middle Coal Measures.

MORGAN'S PIT.

A slant (with steam-winch) descends westward for about 130 yards, measured on the horizontal, to the New Mine Fireclay, which is struck at a depth of 60 yards from the surface. A vertical section at this point would be somewhat as follows:—

Thick Coal (near surface, mostly worked out).	Stone-bottle clay.
Measures.	New Mine Coal.
Heathen Coals with stoneware clays.	NEW MINE FIRECLAY.
Measures with Stinking Coal.	Measures.
	Fireclay Coal.

The beds dip towards the east or north-east.

What is left by previous miners of the Fireclay Coal and New Mine Coal and Fireclay is extracted, but the latter sometimes contains little nodules of ironstone, or is of such an indifferent quality that it is discarded.

Reserves: These are problematical. In 1916 a tunnel was being driven from Morgan's Pit to an old shaft (No. 69 Foxyards Colliery) farther west, to lead off water filling the pit. When this is done some part of the clays and coals up to the Heathen group should be available.

TOMLINSON'S PIT.

A slant at a slope of 30° to 45° follows the New Mine Fireclay downwards from outcrop in a north-eastward direction, and at about 80 yards from the entrance reaches the old workings of Foxyards Colliery Pit No. 69 at a point where the fireclay and overlying beds become nearly horizontal.

The New Mine Coal is 5 ft. in thickness, and the fireclay is sometimes as thick.

The slant passes beneath a large quarry from which the Heathen Coal, and the Thick Coal also, have been got¹ by open-work.

Reserves: These are good for some years.

¹ J. Beete Jukes, 'The South Staffordshire Coalfield' (*Mem. Geol. Surv.*), Ed. 2, 1859, p. 35.

Mode of working: Levels are driven laterally from the slant along the strike of the beds, and the clay is raised by a steam-winch. Weathering of the clays shows up cannocks, which can then be picked out.

WILLIAM MOBBERLEY.

Woodsetton, near Dudley.

Victoria Fireclay and Brick Works and Pit, Hurst Hill.

Works and Mines: Shafts and works situated at Hurst Hill, Coseley.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Staffordshire 67 N.E.

Latitude $52^{\circ} 32' 43''$. Longitude $2^{\circ} 5' 52''$.

Geological formation: Middle Coal Measures.

The pit is situated west of, and close to, the brickworks, but is worked as a separate concern by a group of men who provide the necessary clay, and also some of the coal for firing.

In the following section the chief seams in one of the two shafts are given (Plate I, No. 10):—

	Depth from surface. Ft.
Measures	—
New Mine Coal (4 ft.)	66
New Mine Fireclay	—
'Spoil' (4 ft.)	—
Fireclay Coal (thin)	—
FIRECLAY	84

The seam now worked is the Fireclay Coal with its underclay. The higher seam mentioned is almost exhausted.

At the old Breen Rhyddings Colliery, situated a few hundred yards to the south-east, a fireclay, which may prove to be that of the Fireclay Coal, occurs at 40 yards depth. It is proposed to work towards that objective, approaching first from the north and later from the west.

The colour and texture of the clay varies both vertically and horizontally. Cannocks occur in the floor of the seam.

Reserves: Reserves in surface-dumps will last for a few years, even if no further clay is mined. A little clay is bought from other firms in the district.

Treatment: Weathering is considered necessary, and cannocks are sorted out before milling.

J. BATES.

Ettingshall, Wolverhampton.

Deepfield Works, Rookery Pit and openworks in Ettingshall Park.

Works: Situated about $\frac{1}{2}$ mile south of Ettingshall Station (L. & N.W.R.).

Pit: Rookery Shaft, situated about $\frac{1}{2}$ mile south of the Works.

Maps: One-inch New Ser. Ordnance 167, Old Ser. Geological 62 S.W.; six-inch Staffordshire 62 S.E.

Rookery Pit: Latitude $52^{\circ} 33' 25''$. Longitude $2^{\circ} 6' 13''$.

Geological formation: Middle Coal Measures.

This firm depends upon supplies of fireclay from Himley (Earl of Dudley's Colliery, p. 138) and from local merchants, in addition to their own small supply from Rookery Colliery.

At, or near, the Rookery Pit, the following coals and clays are found:—

New Mine Coal (mostly gone), 5 ft.	Bottom Coal (mostly gone).
New Mine Fireclay (little left).	BOTTOM FIRECLAY and measures.
Fireclay Coal.	Bottom Coal holers (intact), 2 ft. 3 in.
Fireclay (little left).	BOTTOM FIRECLAY (intact).
Measures.	

The Bottom Coal Holers crops out west of the pit, dipping eastward at about 3° , towards the shaft, where it is at 27 yards depth. At the main road farther east it is met with at 135 yards.

Most of Ettingshall Park has been worked over, and is riddled with old surface-workings for coal. The fireclays are still worked in an equally sporadic manner by firms such as Robinson & Co., 3, Spring Road, Lanesfield, Wolverhampton (Old Parkfield Colliery); B. Cole, Ellymore Road, Sedgley, Wolverhampton (Ettingshall Park, Bilston); and Wm. Cope, Ettingshall Park, near Wolverhampton (Ettingshall Park, Wolverhampton).

One openwork (H. G. Duncalfe, Agent) visited in the Park, and situated a few hundred yards north-west of Rookery Pit, was about 15 ft. in depth. The Bottom Coal Fireclay, from 5 to 6 ft. in thickness, resting on a 5-in. coal, was worked here. It has a dark top, the lower part being grey-brown and occasionally iron-stained. It dips N.N.E. at 12° . Most of the fireclays handled by the firm are dark, close and mild at the top, but lighter, more open in texture, and stronger at the bottom. They also vary laterally.

Reserves: Local supplies of clay are small.

Treatment: Weathering is considered an advantage and can-nocks are picked out. Broken bricks and burnt clay are used for grog, and some crushed Bilston Sandstone also is added. Some of the latter rock is ground and used for lining cupolas at a neighbouring foundry.

CHAPTER XII.

COALBROOKDALE AND FOREST OF DEAN.

COALBROOKDALE.

The coalfield of Coalbrookdale extends from north to south for a distance of some ten miles and varies in width up to a maximum of four miles. The beds are only gently folded, but are much disturbed by faults, of which the principal ones run parallel to the boundaries of the coalfield, while others lie nearly at right-angles to this direction. Beds of fireclay higher in the sequence than those found in the south are preserved in the northern parts of the coalfield.

In the absence of detailed geological maps the correlation of the coal-seams in different parts of this coalfield is attended with insuperable difficulties. While the Pennystone Ironstone Measures and the coals from the Best Coal downwards can usually be recognised, the correlation of the coal-seams between these two horizons is as yet confused.

In the following list the principal coals, below the Pennystone Ironstone, and the fireclays worked at the present time, are shown in what are approximately their proper positions:—

<i>Pennystone Ironstone Measures.</i>	
Clays.	Coals.
Clunch Fireclay of Ketley Pit (p. 149)	New Mine Coal of Ketley Pit (p. 149) and of Ladywood Pit (p. 151).
Two-foot Fireclay of Horsehay (p. 152) and Benthall Potteries (p. 153).	Viger Coal of Ladywood Pit = Sulphur or Stinking Coal of Lightmoor Pit (p. 151).
Clunch Fireclay of Lightmoor and Two-foot Fireclay of Benthall Firebrick Works (p. 154).	Two-foot Coal of Ladywood Pit = Sill, Silt or Silk Coal of Lightmoor and ? Clunch Coal of Granville Pit.
New Mine Fireclay of Horsehay (p. 153).	
Ganey Fireclays of Ladywood and Turner's Yard (p. 151) and Bent- hall Potteries.	Ganey Coal of Ladywood ? = Two-foot Coal of Granville Pit.
	Best Coal.
Randle Fireclay of Benthall Fire- brick Works.	Randle Coal. Clod Coal. Little Flint Coal. Lancashire Ladies Coal.

The only fireclay worked above the Pennystone Measures is that underlying the Fungous Coal at about 70 yards above those measures at the Granville Pit.

At the Tuckies Pit belonging to Messrs. Maw & Co. (p. 150), a fireclay is worked at 84 ft. below a sulphur coal, but it is uncertain whether this coal is the Sulphur or Viger Coal of the Middle Measures or one of the pyritous coals in the Upper Measures.

It has been observed that the upper parts of the seams are the richer in alumina.

Formerly other fireclays were worked, such as the Bannoeks, the Clod and the Linseed Earth Seams¹ but none of these is now got, although it is probable that there are reserves at depth. It is doubtful, however, if they could be profitably exploited at present prices.

The average thickness of the seams of clay worked in this district is 3 ft., but the seam that supplies most clay, viz., the Ganey, is divided by a bed of coal, 18 in. thick, into an upper and better part, measuring 2 ft., and a lower part, which is a few inches thicker.

Refractory materials take a subordinate place in the products of this district, which is concerned mainly with the manufacture of tiles (Broseley & Jackfield), sanitary pipes (Horsehay) common pottery (Benthall) and common bricks. Most of the refractory ware is made for the use of the firms making the above-mentioned articles; a small amount is sold locally. Messrs. C. R. Jones and Bennett Bros. prepare ground clay for making saggars in the pottery centres.

The fireclays are usually weathered from three months up to three years, and are blended, dry-ground, screened and pugged. Grog of burnt clay, broken brick or saggars or siliceous stone is added. The firebricks are mostly hand-made, sometimes repressed, occasionally wire-cut and machine-pressed.

Firebricks, blocks, blast furnace and cupola linings, saggars and ladle necks are made.

THE LILLESHALL CO., LTD.

Priors Lee Hall.

Works: The Snedshill Brickworks are beside the main road from Wolverhampton to Wellington, and about two-thirds of a mile south-east of Oakengates Station.

Mines: Two shafts known respectively as the Hydraulic Pit and the Ketley Fireclay Pit supply fireclay to the Brickworks.

The Hydraulic Pit is abandoned, but the dumps are large and are still being drawn upon.

The Ketley Fireclay Mine is situated on the south side of the road to Shrewsbury, and nearly opposite Holy Trinity Church, Oakengates.

Maps: One-inch New Ser. 153, Old Ser. Geological 61 N.E.: six-inch Salop 36 S.E.

Ketley Mine: Latitude $52^{\circ} 41' 30''$. Longitude $2^{\circ} 27' 30''$.

Geological formation: Middle Coal Measures. Clunch Fireclay.

The following is the section in the Ketley Pit:—

				Thickness.			Depth.		
				Yds.	Ft.	...	Yds.	Ft.	...
Made ground and measures	...	...	...	35	0	...	—		
Flint Coal...	...	...	...	1	1	...	—		
Flint	...	...	...	5	0	...	—		
Pennystone measures	...	...	...	3	0	...	—		
New Mine Coal	...	...	...	0	2	...	45	0	
CLUNCH FIRECLAY, working	...	...	...	5	1	...	50	1	

¹ Prestwich, J., *Trans. Geol. Soc.*, ser. 2, vol. v, 1840, p. 413.

Only the topmost 6 ft. of the Clunch Fireclay (the only fireclay worked at this pit) is suitable for refractory purposes. The Clunch Fireclay, which contains many small ironstone-nodes, has elsewhere so far proved useless, because of its low fusing point. At the Hydraulic Pit the seam formerly worked is near the Fungous Coal, but the clay in proximity to this coal in other pits belonging to the company is not suitable for making firebricks.

The general direction of the dip of the beds is south-east at 1 in 12. The Ketley Mine is troubled by faults, the displacements ranging from 3 ft. to 16 ft.

Reserves: It is estimated that the reserves at the Ketley Mine will last at least 15 years. At the Hydraulic Mine there are 16,000 tons of good fireclay on the tips.

Mode of working: The clay is worked on the longwall system. Water is a difficulty, especially in winter, but it can be dealt with by the existing pumping machinery.

Treatment: The fireclay is carefully graded at the pits. At the Hydraulic Pit three qualities were separated when the clay was raised; one, used for mortar only, has weathered on the tips for twenty years; the others are used respectively for first and second-class firebricks.

At the Ketley Mine there are two qualities, the black clay and the grey clay; the black, which contains more alumina than the grey, is used for specially refractory wares.

Maw & Co., LTD.

Benthall Works, Jackfield, Salop.

Works: Close to the mine.

Mine: Tuckies Shaft, situated on south-west side of Severn Valley, and $\frac{3}{4}$ mile north-west of Coalport.

Maps: One-inch New Ser. Ordnance 153, Old Ser. Geological 61 N.E.; six-inch Salop 51 N.E.

Latitude $52^{\circ} 37' 11''$. Longitude $2^{\circ} 27' 25''$.

Geological formation: Coal Measures.

The following is believed to be the section of the Tuckies pit:—

						Thickness.	Depth.
						Ft. In.	Ft. In.
Measures	...	...	...	...	...	129 0	129 0
Sulphur Coal	...	...	...	...	...	2 9	131 9
Measures	...	...	...	...	...	18 3	150 0
Red Clay (used for tiles)	...	...	...	...	...	7 0	157 0
Measures	...	...	...	...	...	53 0	210 0
FIRECLAY (used for refractories)	...	...	...	...	...	6 0	216 0

The measures are nearly horizontal, but they are crossed by a fault.

Reserves: Underground there are large reserves. On the surface there are several thousand tons of clay in process of weathering.

Mode of working: The clay is worked on the pillar-and-stall system; some trouble is caused by the timbers sinking rapidly into the underlying beds. Water is heavy, but at present it can be dealt with by continuous pumping.

Treatment: The fireclay is graded into three qualities. The 'best,' of a dark-grey or purple colour, is said to be of high quality, but is scarce; this is picked out for special purposes.

The 'medium' and the 'common' qualities are weathered together.

The clay is weathered as long as possible, some of it for three years or more. Broken saggars and bricks are used as grog.

The principal products are tiles, which are made from the red clay; the refractory goods form an unimportant part of the industry. The fireclay-goods are used chiefly in the firm's own kilns.

C. R. JONES & SON, LTD.

Jackfield, Salop.

Ladywood Brick and Tile Works.

Works: About $\frac{1}{4}$ mile east of the Ladywood pit.

Mine: The Ladywood fireclay pit, on the south side of the Severn Valley, $\frac{1}{2}$ mile east of Ironbridge Station.

Maps: One-inch New Ser. Ordnance 153, Old Ser. Geological 61 N.E.; six-inch Salop 43 S.W.

Latitude $52^{\circ} 37' 26''$. Longitude $2^{\circ} 28' 28''$.

Geological formation: Middle Coal Measures. Ganey Fireclay.

The section of the measures in the shaft is shown in the following table:—

	Thickness.				Depth.			
	Yds.	Ft.	In.		Yds.	Ft.	In.	
Made ground and measures to bottom of Pennystone gob	23	2	8	...	23	2	8	
White Fireclay (believed to be good fireclay)	1	0	3	...	24	2	11	
Measures	4	2	8	...	29	2	7	
Viger Coal	0	0	6	...	30	0	1	
Viger Fireclay	1	0	6	...	31	0	7	
Two-Foot Rock	4	0	0	...	35	0	7	
Two-Foot Top Fireclay	0	2	4	...	35	2	11	
Two-Foot Coal gob	0	1	2	...	36	1	1	
Two-Foot bottom fireclay	0	1	8	...	36	2	9	
Ganey roof-coal, 6 in.	1	0	3	...	38	0	0	
GANEY TOP FIRECLAY, 1 ft. 6 in.								
Ganey Coal gob, 1 ft. 3 in.								
Ganey Coal (working)								
GANEY BOTTOM FIRECLAY	0	2	0	...	38	2	0	
Measures to bottom of shaft	6	0	0	...	44	2	0	

The Ganey top fireclay, which is black, varies in thickness from 1 ft. 6 in. to 2 ft. The Ganey bottom fireclay, which is grey, is in places 2 ft. 3 in. thick.

Reserves: There is plenty of fireclay underground, but little on the surface.

Mode of working: The clay is worked on the pillar-and-stall system, and is weathered on the surface as long as possible. Troubles arise from the slipping of the ground down the valley-side, which has displaced the upper part of the ground penetrated by the shaft. There is no trouble from water.

THE BROSELEY TILERIES CO., LTD.

Broseley.

Works: At the Dunge.*Mine:* Turner's Yard Shaft, about $1\frac{1}{4}$ mile S.S.E. of Broseley Church, and $\frac{1}{4}$ mile S.W. of Inett.*Maps:* One-inch New Ser. Ordnance 153, Old Ser. Geological 61 N.E.; six-inch Salop 51 N.E.; the other pits are on 51 N.W.Turner's Yard. Latitude $52^{\circ} 35' 57''$. Longitude $2^{\circ} 27' 10''$.

There are also several idle pits belonging to the company and known as:—

(1) The Slang Shaft, at the Dunge Colliery.

Latitude $52^{\circ} 36' 27''$. Longitude $2^{\circ} 28' 5''$.

(2) The Works Shaft.

Latitude $52^{\circ} 36' 26''$. Longitude $2^{\circ} 28' 12''$.

(3) The Deep Shaft.

Latitude $52^{\circ} 36' 39''$. Longitude $2^{\circ} 28' 4''$.*Geological formation:* Middle Coal Measures. Ganey Fire-clay.

Section at Turner's Yard Shaft, formerly owned by the noted Caughley China Works, since removed to Coalport:—

	Thickness.	Depth.
	Ft.	Ft.
Soil, etc.	6	6
Rock	11	17
Fireclay (not worked)	10	27
Bastard red clay	5	32
Fireclay (not worked)	7	39
Rock	24	63
Fireclay (not worked)	7	70
Black bat	4	74
Ganey Top Coal	1	75
Ganey Coal	2	77
GANEY FIRECLAY (working)	4	81
Gob	6	87
Clod Coal	2	89
Fireclay	1	90

Reserves: In the pits the reserves are considered to be large, and there are considerable reserves on the banks also.*Mode of working:* Pillar-and-stall. Water is a serious difficulty, but the existing pumps can cope with it.*Treatment:* The clay is weathered on the tips as long as possible for the firm's own use, but raw clay is sold when ordered.

COALMOOR SANITARY PIPE CO., LTD.

Horsehay.

Works: About $\frac{1}{3}$ mile S.S.W. of the Inn at Coalmoor.*Mine:* Day-levels adjacent to the works.*Maps:* One-inch New Ser. Ordnance 152, Old Ser. Geological 61 N.E.; six-inch Salop 43 N.W.Latitude $52^{\circ} 39' 10''$. Longitude $2^{\circ} 29' 32''$.*Geological formation:* Middle Coal Measures. Two-foot and New Mine clays.

There are two chief seams of fireclay each about a yard thick, and each associated with a seam of coal. These fireclay seams are known as the Two-foot Clay and the New Mine Clay, the former being on top of the Two-foot Coal, the New Mine Clay lies below it.

The Two-foot Clay is the darker of the two in colour and is used for firebricks. The New Mine Clay is mainly utilised for drain-pipes. The beds are nearly horizontal and not much faulted. On the same property (but not worked) there are also the Clod Coal, Randle Coal, Best Coal, and the Little Flint Coal.

Reserves: Underground reserves are considered ample for present demands and possible extensions. They are limited in the direction of the rise to the north-east of the property by the outcrop of the Millstone Grit; in the direction of the strike there are large areas not worked. There is also a large reserve on the tips.

Mode of working: Both clay and coal are worked on the pillar-and-stall system and reached by day-levels.

Treatment: The clay is mined and is weathered on the tips according to circumstances up to $1\frac{1}{2}$ years. The grog added is sand from a decomposed Coal Measure sandstone obtained from a sandhole about 250 yards south of the works.

BENTHALL POTTERIES.

Benthall.

Works: Near the mine.

Mine: A shaft and horse-gin, $\frac{1}{2}$ mile S.E. of Benthall Hall and about 200 yards north-east of the potteries.

Maps: One-inch New Ser. Ordnance 152, Old Ser. Geological 61 N.E.; six-inch Salop 51 N.W.

Latitude $52^{\circ} 36' 57''$. Longitude $2^{\circ} 29' 48''$.

Geological formation: Middle Coal Measures. Ganey Fireclay.

The seam is 35 yards from the surface and consists of a compound seam of coal and fireclay about 6 ft. thick. Another seam called the Two-foot lies above this one but is not now worked.

The beds dip gently towards the east and are crossed by a small fault, which does not much disturb them.

Reserves: There are ample reserves underground. Water presents no difficulties; it is raised to the surface in valve-buckets or let down into deeper workings.

Mode of working: Both coal and fireclay are mined on a modification of the longwall system.

Treatment: The clay is weathered on the tips up to three years. There are few nodules either of ironstone or of iron pyrites in the clay.

THE COALBROOKDALE CO., LTD.

Coalbrookdale.

Works: About $\frac{1}{2}$ mile north of Coalbrookdale Station (G.W.R.). Clay is obtained from old mine-tips in Lawley Coppice, between Lawley and Horsehay.

Maps: One-inch New Ser. Ordnance 152, Old Ser. Geological 61 N.E.; six-inch Salop 43 N.W.

Latitude $52^{\circ} 40' 15''$. Longitude $2^{\circ} 29' 35''$.

Geological formation: Middle Coal Measures. Clunch Fireclay.

Formerly the Clunch Fireclay was dug at Lawley Coppice, but the mines are now abandoned, and only a small quantity of clay remains on the tips.

The Clunch Fireclay was mined at Lightmoor pit also, but this is exhausted and the mine abandoned.

Reserves: Small, and only on the old mine-tips between Lawley and Horsehay.

Treatment: The clay has been weathering for many years on the old tips and requires no further treatment. Grog is added in the form of a siliceous black sandstone obtained from a quarry in the Coal Measures at Stony Hill, about a mile north of the works.

BENNETT BROTHERS.

Benthall Firebrick Works.

Works: Adjacent to Ironbridge Station (G.W.R.).

Mine: Day-levels on the southern side of the Severn Valley about 280 yards west of Ironbridge Station.

Maps: One-inch New Ser. Ordnance 152, Old Ser. Geological 61 N.E.; six-inch Salop 43 S.W.

Latitude $52^{\circ} 37' 34''$. Longitude $2^{\circ} 29' 16''$.

Geological formation: Middle Coal Measures. Ganey, Two-foot and Randle clays.

The following section is exposed at the levels along the coal seams:—

	Ft.
Two-foot Coal	2
TWO-FOOT FIRECLAY	2
Coal, 8 in., partings, 1 ft. 4 in.	2
{ GANEY TOP FIRECLAY	2
{ Ganey Coal	1-2
{ BOTTOM GANEY FIRECLAY	2
Rock	7
RANDLE FIRECLAY	5½
Randle Coal	6
Rock (touched).	

A mixture of all these clays is used but the Ganey Top Fireclay which is dark grey is the best. All the coals are worked, chiefly as fuel for the firm's kilns.

The beds are nearly horizontal or only gently undulating. About a quarter-of-a-mile west of the levels the Silurian rocks are faulted against the Coal Measures.

Reserves: Reserves of fireclay are limited to the pillars left standing after a previous working for coal, but are adequate for many years to come.

Mode of working: The clays are got by two levels, each about 60 ft. long. There is no trouble with water, but the creep of the hill affects the timbers.

Treatment: The clay is weathered for about three months. There are very few nodules of either pyrites or ironstone.

Forest of Dean, Gloucestershire.

In this district only one firm is engaged in the manufacture of refractory goods. These are siliceous firebricks and ground ganister, which are made from some sandstones and sandy clays that crop out at the junction of the Drybrook Sandstone (the so-called Millstone Grit) with the Coal Measures. The beds in question presumably belong to the former, but as no detailed geological survey of the district has been made since the publication of the original one-inch maps in 1845-1872, their exact position in the Carboniferous sequence is uncertain.

The maps referred to show a narrow outcrop of Millstone Grit surrounding the Forest of Dean coalfield. As this outcrop is 27 miles long and averages a quarter of a mile in width, there is evidently no lack of siliceous materials; but it remains to be proved whether these contain much that is suitable for the production of highly-refractory goods. So far as can be seen, the Millstone Grit of this district consists largely of comparatively soft sandstones, and contains little of the pure and highly silicified quartzite that predominates in the Millstone Grit of the neighbouring coalfield of South Wales. Further, in the Forest of Dean there is no extensive steel and iron industry to call forth any considerable output of refractory goods.

The materials actually used for siliceous firebricks are rather soft sandstones and sandy clays, brownish-yellow in colour, with lilac-coloured blotches. A somewhat similar sandstone of a chrome-yellow colour, with occasional pebbles of quartz, is raised for ground ganister.¹

One other firm normally engaged in making red building-bricks from the surface-clays of the Coal Measures has recently experimented in the production of siliceous firebricks from disintegrated (weathered) coarse sandstones of the Millstone Grit, but the attempt was abandoned through shortage of labour.

WILLIAM JAMES.

The Marion Silica Fire-Brick and Ganister Works.

Sunnyside, Coleford, Glos.

Situation: Quarries and works adjacent, on north-eastern side of the Staunton Road, 1 mile N.W. of Coleford. Works established 1770.

Maps: One-inch New Ser. Ordnance 233, Old Ser. Geological 43 S.W.; six-inch Glos. 30 S.E.

Latitude $51^{\circ} 48' 7''$. Longitude $2^{\circ} 38' 0''$.

Geological formation: Top of so-called Millstone Grit or base of Coal Measures.

¹ Special Reports on the Mineral Resources, vol. vi, Ganister and Silica-rock (Mem. Geol. Surv.) Ed. 2, 1920, p. 104.

The section at the northern end of the quarry is as follows:—

	Ft.	In.
1. Overburden (rejected), about	1	6
2. Sandstone, soft, brownish-yellow, with a line of quartz-pebbles at base	3	0
3. Sandstone, similar though harder	5	0
4. Sandstone and sandy clays, variegated with yellow and lilac-coloured blotches	6	0
5. Sandstones, harder (floor of quarry)	1	6
6. Clay, not bottomed	—	—
	17	0

Bed 3 thins down in other parts of the quarry to 2 ft. No. 4 passes southward into sandstone, or thins out between Nos. 3 and 5. Beds 2, 3 and 4 are all raised and mixed together for the manufacture of siliceous firebrick goods.

The beds dip E. 20° N. at 6° to 8° .

Reserves: The materials available may be limited downwards by the clay (6), the thickness of which appears not to have been proved. Along the strike there are large natural reserves, and in the direction of dip the amount is sufficient for some years. The bottom of the quarry reaches water-level, but the resulting water can be dealt with.

Method of working: The stone is worked by open quarrying along a vertical face parallel to the strike. The harder and larger lumps are broken by hand to the size of road-stone.

Treatment: The raw materials are not weathered or selected. They are ground in a solid-bottomed ('wet') pan under light edge-runners. The ground material is hand-moulded into bricks of various shapes, and boiler seaters, etc. These are dried on floors heated by coal fires and then fired in round kilns. One of these is an updraught, convertible at will into a downdraught by the closing of the top and the opening of a trap in the floor; the other is permanently updraught. The firing is judged by inspection of the kiln through peep-holes. Fuel is bought locally.

No extraneous materials or grogs are used in the mixture, as at present the face of the quarry yields the different materials in proportions suitable for the goods produced. The firebricks are of a pale-red colour.

CHAPTER XIII.

THE SOUTH AND WEST OF ENGLAND.

CORNWALL.

The material actually employed at the present time for firebrick in Cornwall is the decomposed granite or China-clay rock. This is a mixture of angular quartz grains, kaolin, mica and partially decomposed felspar. It is easily dug with pick and shovel, and it may also be disintegrated by allowing a stream of water to flow over the roughly broken rock or by hydraulicing.

The principal centre for the decomposed rock is the granite mass of St. Austell, where it is excavated from innumerable pits for extraction of the kaolin or china-clay. The area next in importance is the similar granite mass of Bodmin Moor; other much smaller occurrences are at Breage and Hingston Down, Calstock.

The china-clay rock may be used direct for firebrick and it requires only grinding and pugging to make a plastic mass ready for the moulds. This is the practice at Chilsworthy and Carbis. At the latter place if the material carries too much clay for the work in hand, some of the quartz waste from the china-clay dump is added.

On the other hand the process of extracting the china-clay from the rock leaves great quantities of residues, *e.g.*, quartz-sand, 'mica-clay,' and the coarser sediment from the 'micas' or settling troughs, and in some cases it is found more convenient to employ these in suitable mixtures rather than work on the raw material.

This course is adopted at the Carloggas works of the West of England and Great Beam Clay Company where a very satisfactory firebrick is made from a mixture consisting of equal parts of (1) fine sandy residue from the 'micas,' (2) mica clay, (3) sand waste. The bricks are fired to 1320° C.

These waste products of the china-clay industry will yield an immense store of material to one who will find a satisfactory method of dealing with them.

In the Calstock district firebricks were formerly made at the Calstock Works on Hingston Down from a mixture of red mica schist, decomposed sandy elvan, and soft white and yellow killas. In the same neighbourhood the Phoenix Works, now dismantled, worked pits in an east-and-west elvan dyke and made firebricks of this material mixed together with the adjoining bleached and iron-spotted killas. About a quarter of a mile east of the Phoenix Works, terra-cotta goods were made from the same killas and elvan at the Tamar Works.¹

¹ 'The Geology of the Country around Tavistock and Launceston' (*Mem. Geol. Surv.*), 1911, p. 130.

The refractory products of Cornwall consist mainly of fire-bricks, boiler blocks and kiln tiles for the china-clay works, mostly for local consumption. At Chilsworthy, coke-oven bricks and Admiralty bricks also are made, the firing temperature being 1350° C. Carbis (below) has lately made shapes for gas works, and a setting clay is made by reducing the amount of free sand in the stock material.

HILL, WESTLAKE & Co., LTD.

Head Office—13, Portland Street, Southampton.

Chilsworthy Pit, Gunnislake.

Works: Situated on the southern side of the railway, and close to Chilsworthy Station.

Pit: Adjoining the works, 150 yards south of the railway.

Maps: One-inch Ordnance and Geological 337; six-inch Cornwall 29 N.E.

Latitude $50^{\circ} 31' 30''$. Longitude $4^{\circ} 14' 0''$.

Geological formation: Granite of Hingston Down.

The excavation is situated in a kaolinized patch of granite. The material closely resembles the china-clay rock of other districts in Cornwall and had formerly been tried as a source of china-clay, but the rock is too much stained for that purpose. The bulk of the material is pale grey; patches having a pink or yellow stain are prevalent. The pit is about 100 yards square and about 50 ft. deep on the southern face; the overburden varies from 5 to 8 ft. thick. Quartz veins, with iron stain traverse the rock from north to south, and greissen veins run east and west; these and an occasional mass of less decomposed rock constitute the only waste in the pit.

Reserves: The lateral extension of the decomposed granite has not been proved though it no doubt reaches some distance beyond the limits of the openworks. The kaolinized rock is said to have been proved to a considerable depth without touching bottom and the reserves are therefore regarded as large.

THE CARBIS BRICK & TILE WORKS.

Carbis, near Roche.

Situation: Works and pit about $\frac{3}{4}$ mile east of Roche.

Maps: One-inch Ordnance and Geological 347; six-inch Cornwall 41 N.E.

Latitude $50^{\circ} 23' 50''$. Longitude $4^{\circ} 49' 0''$.

Geological formation: Decomposed granite of the St. Austell mass.

The small pit, about 15 ft. in the deepest part, exposes soft decomposed granite (china-clay rock) in colour ranging from white to a strong pink. The colour deepens towards the west.

An analysis¹ of the clay portion of this rock gave SiO_2 46.25,

¹ 'A Handbook to the Collection of Kaolin, etc.' (*Mem. Geol. Surv.*), 1914, p. 191.

Al_2O_3 , 36.34, Fe_2O_3 , 1.21. The colour, which is most probably due to finely divided ferric oxide, is discharged on firing, leaving a white body.

Reserves: The pit is small and much of the adjacent ground has been turned over in the past, but there has been no attempt to deepen the excavation though the 'clay' is said to have been proved to the depth of 70 fathoms. Reserves are presumably large.

Devonshire.

Refractory materials in Devon are obtained from the granite of Dartmoor and the Oligocene Beds of the Bovey and Torrington Basins.

(1) *The Dartmoor Granite.*

The granite is strongly kaolinized in places, particularly upon the southern border of the mass where it has been worked for many years for china-clay. As a source of refractory material the rock is similar to that in Cornwall. Firebricks of all kinds, blocks and kiln tiles are made at the Lee Moor Works of Messrs. Martin Bros. The reserves of raw material are enormous.

(2) *The Oligocene Beds.*

These beds occupy two remarkable depressions in the older rocks. In the better known Bovey Basin the Oligocene strata are surrounded by and rest upon Devonian rocks; in the Torrington Basin the older rocks are of Carboniferous age.

The Bovey Basin extends from about Newton Abbot in a north-westerly direction, a little beyond Bovey Tracey; it has a maximum length of six miles, and a maximum breadth of two miles. The rocks exposed in openworks and shallow clay mines are alternating beds of sand, argillaceous sand, and clay with deposits of lignite. The valuable clays are for the most part plastic ball clays and stoneware clays, both of which exist in many varieties; it is for these clays that the numerous open pits and mines are worked. The beds apparently dip toward the centre of the basin.

Borings about the centre of the basin have revealed a great thickness of these mixed deposits: at Heathfield they were proved to a depth of 456 ft., and at Teigngrace to 667 ft., without reaching the older rocks.

The beds recorded show a long range of material applicable to the manufacture of firebrick, etc., from almost pure clean sand through many grades of sandy clay to tenacious fat clays. The reserves are very large indeed.

The wares produced in this district, comprise firebricks, buff facing bricks, glazed bricks, acid proof bricks, paving bricks, sanitary ware, pipes, enamelled tiles, fireplaces, etc. Firebricks were formerly made at the Bovey Pottery from similar materials.

The Torrington Basin is situated in North Devon; its north-western extremity being about 3 miles due south of Torrington. The deposit occupying the bottom of the depression covers an area

roughly 4 miles long and 1 mile wide, with the village of Merton on the north, Petrockstow on the south, and Meeth on the south-east side. The materials filling the hollow resemble very closely the sands, clays and lignites of the Bovey Basin, and they may be of the same geological age, though no proof of this has yet been obtained.

As in the Bovey Basin, the principal products are raw clays, for example, blue ball-clay, pipe-clay, stoneware-clay. The bricks made at Marland comprise buff facing bricks, vitreous stoneware facing bricks, and buff or brindled acid-proof bricks. Firebricks have not been made on a commercial scale but there is abundant material for the manufacture of siliceous firebricks.

MARTIN BROS., LTD.

Head Office—20, Lockyer Street, Plymouth.

Lee Moor Firebrick Works.

Situation: Brickworks are attached to Lee Moor China-clay Works on the south-west flank of Dartmoor, about 4 miles by road from Cornwood Station (G.W.R.), and about 3 miles from Bickleigh Station on the Launceston Branch (G.W.R.). A full-gauge railway connects the works with the main line at Plympton.

Maps: One-inch Ordnance and Geological 349; six-inch Devon 118.

Latitude $50^{\circ} 25' 50''$. Longitude $4^{\circ} 1' 0''$.

Geological formation: Decomposed granite of Dartmoor.

The materials used in the manufacture of firebricks are not quarried specially for the purpose but are obtained as a by-product of Messrs. Martin's great China-clay Works.¹

In the process of washing the china-clay from the kaolinized granite two forms of residue are obtained, (1) a slightly inferior china-clay, the 'mica clay,' (2) rough quartz 'sand.' These are the materials employed by Messrs. Martin for all varieties for firebricks and for kiln tiles.

The mica clay is obtained in the usual manner and stored in pits adjoining the brickworks. The sand is graded and at the same time washed by passing it through revolving screens under a constant stream of water.

CANDY & Co., LTD.

Heathfield Station, near Newton Abbot.

Situation: Works and pit adjoining Heathfield Station.

Maps: One-inch Ordnance and Geological 339; six-inch Devon 101 S.W.

Latitude $50^{\circ} 34' 15''$. Longitude $3^{\circ} 38' 55''$.

Geological formation: Oligocene beds of the Bovey Basin.

The Heathfield pit is situated at about the centre of the basin; it has been worked for many years and is now over 70 ft. deep.

¹ 'A Handbook to the Collection of Kaolin, China Clay, etc.' (*Mem. Geol. Surv.*), 1914, p. 15.

The following details have been measured recently¹:—

	Ft.
1. Overburden	6
2. Pale clay and fine sand in thin layers	15-20
3. Coarse quartz sand	3
4. Pale bluish-white clay	6-12
5. Pale brown clay	6
6. Blackish brown clay with large fragments of lignite...	3½
7. Lignite	1
8. Brown clay with fragments of lignite	2
9. Pale brown clay	10
10. Bluish-grey ('fat natured') clay	9

The beds dip W.S.W. at 10°.

For the manufacture of firebricks the beds 2, 3 and 9 are used in about equal proportions. All the other beds in the pit are employed; bed 4 for best quality pipes and glazed bricks, bed 5 for pipes, beds 6 and 8 for common brick, bed 10 for paving blocks, etc.

Reserves: Along the dip and strike and in depth also reserves are large.

HEXTER & BUDGE.

Clay Mines, Kingsteignton, Newton Abbot.

Works: Kingsteignton (Hexter, Humpherson & Co., Ltd.).

Pit: The Broadway Pit, 1,000 yards N.W. of Oakford Cross, Kingsteignton, about 1 mile from the works.

Maps: One-inch New Ser. Ordnance and Geological 339; six-inch Devon 109 N.E.

Latitude 50° 32' 55". Longitude 3° 36' 20".

Geological formation: Oligocene beds of the Bovey Basin.

The large open pit shows on the western side the following section:—

	Ft.
Overburden	—
1. Coarse quartzose sand	6-10
2. Stoneware clay	12
3. Sand bed	6

On the eastern side:—

4. Clay, 'black alum'	5
5. Clay, 'white alum'	5
6. Stoneware clay	4½
7. Pink clay	6

The bulk of the output of this pit consists of the stoneware and fatter clays. The raw material used for firebricks is obtained from bed No. 1 and part of No. 2. These are mixed in the proportion of two-thirds sand to one-third clay.

Reserves: The beds crop out to the east of the pit, the dip being almost due west. There are ample reserves toward the dip.

¹ Special Reports, vol. vii, pt. i (*Mem. Geol. Surv.*), 1918, p. 12.

THE NORTH DEVON CLAY CO., LTD.

Torrington, North Devon.

Works: The Marland Stoneware Brick Works, situated at Clay Moor, 4 miles due south of Torrington.

Mines and Open Works: Several independent shafts, known as the North Devon Mine, and large openworks, situated on Marland and Grange Moors, south-east of the works.

Maps: One-inch New Ser. Ordnance 309, Old Ser. Geological 26; six-inch Devon 41 S.W.

(Mines.)^{*} Latitude $50^{\circ} 53' 20''$. Longitude $4^{\circ} 6' 30''$.

Geological formation: Oligocene (?).

The deposits in this basin resemble those in the Bovey Basin, that is to say, they consist of plastic clays, stoneware clays and argillaceous sands with subordinate lignitic beds, with a variable overburden of gravelly 'head.' The dip of the beds is generally towards the centre of the basin, but many of the beds are lenticular. On the north-eastern side the dip varies from 45° to 15° . The bottom of the basin has not been proved.

Reserves: Firebricks have not yet been made for sale, but trials made with the more sandy material were promising, bricks being produced that commenced to sinter at 1800° C. Of suitable material there are very large reserves.

Mode of Working: The mines are inclined shafts that follow the dip for about 500 ft. At the bottom drifts are cut for about 30 to 40 ft. to the right and left, and when the good clay has been removed from these, excavation is gradually extended up the dip, so that a breadth of 60 to 80 ft. of the bed is removed from each shaft.

The open pit is terraced to permit of the removal of the clay in cubical 'balls.'

Surrey.

STONE & Co., LTD.

Epsom and Ewell, Surrey.

Situation: Two large open pits are situated on either side of the main London road a short distance east of Epsom; another pit is worked at the Nonsuch Pottery a little north-east of the Church at Ewell.

Maps: One-inch New Ser. Ordnance 270 and 286, Old Ser. Geological 8; six-inch Surrey 13 and 19.

(Epsom.) Latitude $51^{\circ} 20' 30''$. Longitude $0^{\circ} 15' 25''$.

(Ewell.) Latitude $51^{\circ} 21' 15''$. Longitude $0^{\circ} 14' 30''$.

Geological formation: Eocene, Woolwich and Reading Beds.

The bed of yellowish-grey sandy loam employed for making a refractory brick is only from 9 to 18 in. thick. It occurs in the midst of the usual mottled clays, loams and sands characteristic of the Woolwich and Reading Beds in this region. The

following section was measured on the south-east working face of the Ewell pit:—

		Ft.
	Soil	1
Pleistocene	Clay and flint gravel, 'Uncallow'	8-15
	White clay with 'race'	2-3
	Mottled red and green clay	11-12
	Grey sandy loam 'Nonsuch fireclay'	1-1½
Woolwich	Glauconitic loamy sand 'strong brick clay' ..	4½
and	Pebbles and sand	½
Reading	Glauconitic sand with purple shale 'mild	
Beds.	brick earth'	4½
	Bright red laminated clay	
	Pebble bed	
	Hard blue clay	7
Thanet	Grey sand	7
Sand.	Brown sand	3+

Section in the Epsom pit on the west side of the main road about half a mile east of Epsom:—

		Ft.
	Soil	1
Pleistocene	Clay with flint gravel ('Bunkum' or Uncallow)	7-10
	Mottled red and brown clay with 'race'	4
	Grey sand 'Nonsuch fire-earth,' locally	2-3
Woolwich	Mottled red and pale green, unctuous clay,	
and	'strong mild'	3
Reading	Yellowish green loam, 'rubber dirt'	1
Beds.	Yellow loam with oysters	2-3½
	Black pebbles and sand	1-1
	Green sand	1

This brickearth has been worked continuously since the days of Henry VIII. Lysons¹ quotes the following from Leland:—

"Crompton of London hath a close by Codington in Southerey, wher the King buildith [Nonsuch Palace]. In this Close is a vaine of fine yerth to make mouldes for Goldesmithes and casters of metale, that a loade of it is sold for a croune of golde. Like yerth to this is not found in all Englande."

The Nonsuch brick earth is a ferruginous loamy sand. Analysis shows it to have the following composition:—silica 87·5, alumina 3·6, iron oxides 4·8 per cent. The brick is dull red in colour and soft so that it may be easily rubbed or sawn. It has been employed in many gasworks and is said to become very hard and more refractory after intense heating.

The main output of the firm is derived from the other clay beds. it consists of red bricks, stocks, chimney and flower pots and tiles.

Sussex.

Maps: One-inch New Ser. Ordnance 320, Old Ser. Geological 5; six-inch Sussex 58, 59, 71.

The Lower Cretaceous Wealden Series so well developed in Sussex, Kent and parts of Surrey contains many beds of clay,

¹ 'The Environs of London' vol. i, 1792, p. 158.

some of which have been employed for common brick for many years. Little, however, is known of the economic properties of the clays.

In attempting to find material similar to that used in Belgium for certain classes of firebrick, experiments have been made by the Brymbo Steelworks Company on the Fairlight Clays exposed in the cliff between Ecclesbourne Glen and Fairlight Glen, one to two miles east of Hastings.

The geological position of the Fairlight Clays is indicated below:—

Wealden ...	...	{	Weald clay	...	{	Tunbridge Wells Sands.
			Hastings Beds	...		Wadhurst Clay.
						Ashdown Sand and Fairlight Clays.

The Fairlight Clays occur as a local phase of the Ashdown Sand and themselves contain many sandy beds. These clays attain a thickness of 360 ft. in the neighbourhood of Hastings and Fairlight, and the bottom is not seen. They are covered by about 150 ft. of sands, to which the term Ashdown Sand is locally restricted.

The clays are mottled, red and yellow, grey, and occasionally white; the majority are decidedly sandy.

The following partial analyses were made by the firm:—

SiO_2		Al_2O_3		Fe_2O_3
78.30	...	14.00	...	1.50
57.25	...	24.26	...	5.20
72.00	...	18.00	...	2.60
78.00	...	13.44	...	0.96

Stamford District.

In this area the Upper Estuarine Series consists of clays, occasionally very sandy, and always liable to rapid changes of character when traced along the outcrop. The prevalent tint is pale blue, but green, purple and dark grey are not uncommon. For practical purposes much of the clay is spoiled by the presence of fossil shells, wood and calcareous concretions. This formation is rarely more than 30 ft. thick, often it is much less; it is found either as a capping to the Inferior Oolite limestone or forming steep slopes on the valley side between the Great Oolite limestone above and Inferior Oolite below. At the base of the clays a thin band of nodular limestone is usually present.

These clays have been dug for brick making at Stamford, Great Oakley, Water Newton, Wood Newton, between Stanion and Brigstock, and between Pilton and Luffenham. At Little Bytham the clays from the lower part of the series were formerly made into bricks called 'clinker' bricks on account of their hardness and durability. At Wakerley on the same horizon a fireclay used to be dug and taken to Stamford for making muffles and also for a terra-cotta mixture.

The outliers of the clay are well exposed along the strike in the well-known Ketton, Little Casterton and Clipsham limestone quarries.

The section formerly exposed in the old clay pit at Stamford,

known as Torkington's Pit, gives a good idea of the general characters of the deposit.

	Ft.
1. Soil	1½
2. Oyster beds of Great Oolite limestone	3
3. Dark-coloured, nearly black, carbonaceous and ferruginous clay, without shells	3½
4. Grey clays, with shells	3
5. Clays of a tea-green colour, sometimes passing to a bright green, and crowded with shells	5½
6. Black, carbonaceous bed, without shells	1-2
7. Green clay (without shells but with masses of jet)	2
8. 'Skerry,' a hard gritty clay used for making fire-bricks, it resembles in texture the 'root-beds' but has no vertical plant remains	¾
9. Grey clay, blackish in places (but makes fine white bricks and is esteemed the best clay in the pit)	4
10. White clays, very sandy in places	5
11. Light reddish-brown clay, full of wood	1
12. Ironstone junction-band	1
13. Limestone (Lincolnshire Oolite)	74
14. Sands and ironstone of the Northampton Sand	—

In the "Skerry" (8) and the clays below it iron-pyrites abounds. The total thickness of the Upper Estuarine Series here is 27 ft.

The upper clays burn into a red brick, the "skerry" into a firebrick, and the grey clays (9) into a fine white brick.

A section of the clays seen north-west of Stamford is as follows:—

		Ft.	In.
Upper Estuarine Series.	1. Great Oolite limestone	3	6
	2. Sandy and ferruginous clay	4	0
	3. Blue and brown clay	2	0
	4. Banded green and grey shelly clay	4	0
	5. Purplish, green and grey clay	4	0
	6. White and grey, purplish carbonaceous clays with selenite, and sandy layers with rootlets	11	0
	7. Dark red ironstone	0	5
	8. Ferruginous clay	0	3
	9. Lincolnshire Limestone	—	

WILLIAMSON, CLIFF, LTD.

Fireclay Works, Stamford.

Situation: The works and open pits are situated on the Little Casterton road about 1 mile north-west of the centre of the town.

Maps: One-inch New Ser. Ordnance 157, Old Ser. Geological 64; six-inch Lincoln 150 N.E. (Rutland 10 N.E.).

Latitude 52° 39' 20". Longitude E. 0° 30' 20".

Geological formation: Jurassic, Great Oolite, Upper Estuarine Clays.

The clays worked in the shallow open pits, lie without any appreciable dip and rest upon the Lincolnshire Limestone of the

Inferior Oolite which is worked in several neighbouring quarries. The following section is exposed:—

								Ft. In.
Cover: earthy clay and rubble	...	...	...	...	...	...	...	2 6
(1) Pale grey clay	...	...	...	...	...	...	...	4 6
(2) Darker clay	...	...	...	...	...	...	...	3 6

The upper half of the grey clay is paler than the lower. The darker clay is rather stiffer than the pale grey clay and contains fragments of carbonaceous matter.

Reserves: The reserves cannot be considered very large because of the possibility of changes in character as the clay is followed along the bed, but there is sufficient for many years at the present rate of consumption and new sites for pits could probably be found along the outcrop.

These two clays are used in various proportions as the basis of all the products of the firm, but mixtures are made with numerous imported clays for special purposes.

The products include handmade gas-retorts, all kinds of fire-bricks, coke oven bricks, cement-mill blocks, tiles and special bricks faced with the higher refractory materials.

CHAPTER XIV.

NORTH WALES.

FLINTSHIRE : BUCKLEY FIRECLAYS.

INTRODUCTION.

The Buckley Fireclay group forms the highest part of the Middle Coal Measures of Flintshire and occurs a short distance above the Hollin Rock, a sandstone that overlies the Hollin Coal. The beds exposed, which belong to the lower half of the group, have a thickness of somewhat over 100 ft., of which the upper part is mainly sandstone, the lower part being largely clays. These exposed strata are quarried near Buckley. The whole group has been proved, in a boring at Tirlas-gôch, north of the Elm Colliery workings, Buckley, to be about 400 ft. in thickness.

The Fireclay group might be regarded as a transition group between the Middle and Upper Coal Measures, but that it occupies roughly the same position above the Main Coal as the Cefn Sandstone of Denbighshire, which belongs essentially to the Middle Measures and lies some distance below the red Ruabon Marls. These Buckley Beds may best be considered as indicating a partial, local and temporary anticipation of Upper Coal Measure conditions, at a stage at which Middle Coal Measure conditions prevail further south.

The fireclays occur in a broad shallow syncline, of which the axis extends south-eastward from Flint by Northop Hall and Ewloe Green, and the exposed beds lie south of the synclinal axis between Northop Hall and Buckley Station. The syncline is crossed by faults trending between north and north-west, mostly with westward downthrow, and some of these, co-operating with the general eastward dip of the beds, have produced three separate outcrops¹ that are free from Glacial drift:—

- (a) Along the course of the Altami Brook, where the beds are at present unworked.
- (b) Along a N.N.W.-S.S.E. line between the Castle Brickworks and the east end of Buckley Mountain.
- (c) On a nearly N.-S. line between Ewloe Hill and Lane End, Buckley.

These areas, and the faults separating them, are shown on the recently surveyed 6-in. Geological map (Flintshire, 14 N.W.).

In the north-west the outcrop (a) is separated from the north end of the central outcrop (b) by at least three large faults with westward downthrows.

The central outcrop (b) is bounded on the east by a large fault, down west, which throws the Buckley Beds against the Coal Measures that are locally capped by the Hollin Rock. The

¹ See also C. B. Wedd in Summary of Progress for 1913 (*Mem. Geol. Surv.*), 1914, pp. 14-16.

throw of this fault becomes less towards the south and therefore crosses the outcrop of the eastern beds obliquely; hence we find

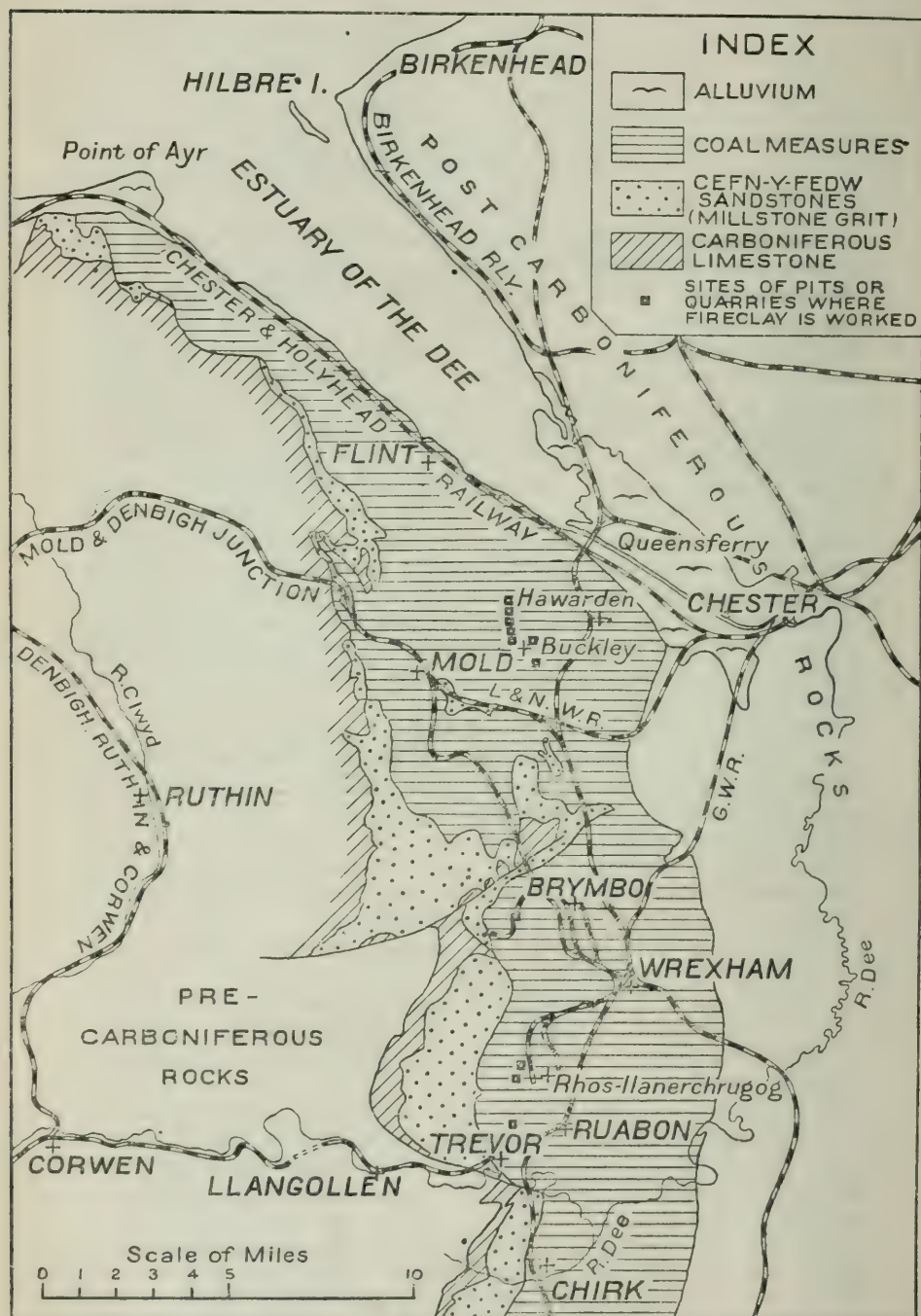


FIG. 10.—Map of the Buckley—Ruabon Clay area.

that the lower Buckley Beds of outcrop (c) overlying the Hollin Rock are, in their turn, brought into contact with the higher Buckley Beds of outcrop (b).

Although the fireclay group crops out only in the neighbourhood of Buckley, Mr. Wedd considers that there is reason to believe that the beds have a wider distribution under the Glacial drift, and that they are present in the north of Flintshire wherever the upward sequence of Middle Coal Measures continues above the Hollin Rock, *e.g.*, at Mold, and perhaps Mancot (near Hawarden) and Bagillt.

In the central outcrop (b) the sequence exposed in the quarries is as follows, in descending order:—

6. Purple shaly clay, with local developments of pale-green clayey shales and thin quartzose sandstone.
5. Sandstone, massive, quartzose, fine-grained, usually yellowish-white, but rather felspathic and pinkish in some of the higher beds, forming a well-marked bed and weathering with a purplish-brown crust, with subordinate beds of shale and fine-grained white siliceous clunch. This passes down into
4. Siliceous clay or silt-rock, greenish-white, very fine-grained and sporadically developed—on, or sometimes mixed with
3. Mottled purple clay, usually split up by a bed of white siliceous clunch. This clay is termed 'Blue.'
2. Shaly clay, dark-grey or black, sometimes with thin coal-seams; replaced northward almost entirely by red and grey blotched warrant and (locally) quartzitic sandstone.
1. Coal, thin, becoming a mere streak of carbonaceous shale towards the north.

All the beds are variable in character; in one part over 30 different kinds of raw material are handled. Nos. 3 and 5 appear to be the most permanent members of the group, but even they vary a great deal from point to point in the same quarry.

In the eastern outcrop (a) the beds are more persistent on the whole, especially the black clay. Below the thin coal a soft grey shaly clay or warrant, with ironstone-nodules, has been proved to overlie the Hollin Coal.

Along the course of the Altami Brook, west of the Castle Brickworks quarry, Mr. Wedd has proved the occurrence of all the beds from the quartzitic sandstone at the top of the black clay division up to the highest thin quartzose sandstone mentioned in the above sequence, which forms a broad dip-slope in the wood west of the quarry.

The chief products manufactured from the Buckley Beds are acid- and fire-proof goods, but paving- and ridge-tiles and common bricks also are made.

It is necessary to make careful blends of the raw materials, and to keep a strict watch upon any variations the beds may undergo as they are followed during quarrying operations. In consequence a constant series of experiments and analytical tests must be maintained as the different clay-pits develop. Frequently the

same strata, while presenting to the eye exactly the same appearance, change in ferric oxide content, and, still more unfortunately, in ferrous oxide content, the former rising sometimes to 7 per cent., less frequently to 10 per cent., and occasionally to as much as 19 per cent. When the content of ferric oxide exceeds 7 per cent., or of ferrous oxide 4 per cent., the rock may have to be rejected¹. An ordinary Buckley firebrick contains about 5 per cent. of ferric oxide.

Buckley firebricks are of two kinds—the reddish-blue, purple or 'brindled' brick, and the 'white' brick, the latter being made chiefly from the black clay, the former from blends of the more siliceous beds with purple clay.

At some firms the clays, after being blended and passed through rollers, are thoroughly mixed and tempered by a process referred to as the 'treading.' In other cases the usual methods of crushing and mixing are employed.

The 'treading' is conducted in a large pan varying from 16 to 30 ft. in diameter, and about 2 ft. in depth. A revolving beam, trenched by small channels which are filled with water, and the with iron, is caused to rotate about the central axis of the pan by the movement of an overhead arm driven by power. Water is put into the bottom of the pan, which is then filled with small broken cakes of clay from the rollers. The surface of the clay is trenched by small channels which are filled with water, and the whole is allowed to stand for 12 hours. The 'horse' is then set in motion and the clay thoroughly pugged by the treading of the legs. In former days it was the practice to employ horses to tread the clay, their legs being protected by leather gaiters.

The 'brindled' goods require special firing. The kilns are of the circular beehive shape, with outside fires and down-draught flues, which are so arranged that the waste heat may escape by the chimney, or, in some cases, by way of the drying-floors.

During the last 14-15 hours of firing the chimney-flue is shut and the flue to the drying-floor slightly opened, and the fires are stoked up. As little air as possible is admitted in order to set up a reducing action which deprives the brick of the oxygen and produces a uniform 'brindled' or blue tint. A wrongly-burnt or 'aired' brick has a white centre. It is said to be as good a fire-resister as a properly tinted brick, but it is not acceptable to the users, who doubt its quality. There may therefore be a good deal of waste in firing the Buckley Clays. It is, however, not underburnt. A blue colour is essential for a Buckley ridge-tile, and tiles and firebricks are fired together. They are fired at approximately 2500° F. (1370° C.), and fuse at about 3100° F. (1704° C.), and crack only slightly at a pressure of 3890 lbs. to the square inch.

Buckley firebricks will not stand the high temperature of steel-furnaces, but do well for purposes where such great heat is not required, and in situations where abrasion is high and strength

¹ According to Chas. Davison & Co., Ltd.

is necessary, such as in the tops of blast-furnaces, furnace doors, and the exposed outsides of furnaces. They resist well the action of alternate heating and cooling.

The bricks have also been used extensively for railway tunnel and bridge work, and will withstand great hydrostatic pressure. Flooring-tiles made of the fireclays are in request for paving mill-floors near machinery. They give secure foothold and wear well, and by absorbing waste oil prevent dangerous slips. White firebricks are used in furnaces where continuous heat is applied, as in tin-smelting works and steam-ships.

The acid-resisting goods are used in the construction of Glover, Gay-Lussac and hydrochloric acid towers, etc.

In many cases the brickyards have been built on the wrong sites, viz., on the strike or on the 'dip' side of the beds of economic value, where their position renders development of the quarry impossible. A true appreciation of the geological structure would have resulted in all the brickyards being correctly placed on the western sides of the pits, where the beds below the workable clays run out at the surface. (*See appended large-scale map, Fig. 11.*)

Flintshire.

CATHERALL & CO., LTD.

Buckley, Chester.

Ewloe or Trap Works and Quarry.

Location: Situated a little over $\frac{1}{2}$ mile N.W. of Buckley Church.

Maps: One-inch New Ser. Ordnance 108. Old Ser. Geological 79 S.E.; six-inch Flint. 14 N.W.

Latitude $53^{\circ} 10' 50''$. Longitude $3^{\circ} 4' 50''$.

Geological formation: Middle Coal Measures.

The face of the section runs about north and south, and the beds dip towards the east at about 10° . They vary considerably when traced along the strike.

Section at south end of quarry, 1913. [C. B. Wedd.]				Section at north end, 1916.			
			Ft.				Ft.
Sandstones, about	...	...	10	Red sandstone, with pockets of 'blue' clay and red marl.			
				Yellow sandstone.			
Top 'Blue' [purple] Clay	...	...	2	Top 'Blue' Clay...	...	...	} 20
White Rock [sandstone]	...	...	15	White bed	...	...
Bottom 'Blue' [purple] Clay,	...	...	10	Bottom 'Blue' Clay	...	...
very variable, about	...	...	10	Black Clay, below floor of pit.			
Black [dark grey and black] shaly fireclay, seen for about	...	...	18				
8 ft. up to	...	...	18				
			55				
			—				

The junction between the red and the yellow sandstone is occasionally sharp; in places, however, there appears to be a lateral passage between the two. The red stone runs out at the surface at the north end of the quarry; it contains iron and about 85 per cent. of silica. The yellow rock is a bastard sandstone, in part shaly and frequently laminated. Some of it breaks down to plastic material on weathering.

At the top of the Top Blue Clay there is a pale greenish-white clay of high silica-content. It varies in thickness from point to point, and is in places absent.

At the south end of the pit the Top Blue Clay is missing, and the White Rock forms the lower part of the sandstone. When traced northward the Top Blue Clay appears as a thin band which becomes thicker, whilst the White Rock becomes thinner but persists for some distance as a 6-ft. bed of pale greenish-grey or white clunch, after which it becomes purplish but retains its silica-percentage.

The middle of the pit is not worked at present. Hereabouts a 4-ft. bed of hard white siliceous clunch, said to be too tough to be of value, develops in the Bottom Blue Clay and bends up southwards until it is truncated by the White Rock. Other small siliceous bands and patches occur here and there in the higher parts of the Top Blue Clay.

The Black Clay is a dark-grey to black shaly clay with no lime. It is the equivalent of the black shale and 'warrants' of Parry's and other pits farther north.

Reserves: An area of about 30 acres of proved ground still remains to be worked in the property, but the dip will carry the beds to a lower level as the quarry-face moves eastward. Work is being carried southward also along the strike.

Beneath a small coal below the black fireclay there is a bed of fireclay that is not yet worked, and from which firebricks can be made in future. This coal is the same as that in the Brookhill Pit to the north.

Mode of working: The beds have been worked down-dip from outcrop and now stand in a vertical face. Shot-holes are drilled by hand in the purple clays, which are blown out and pillars are left to support the sandstones. On removing the pillars the overlying beds fall into the pit as a confused mass, from which the different types of rock must be sorted by hand. Lumps of the sandstone require further blasting.

Water collects after rain, and is led to the middle of the pit, which acts as a reservoir. In winter it is pumped into surface-ditches.

Treatment: Fire-resisting goods are made from mixtures of raw material; of these we may mention:—

Sandstone mixed with varying proportions of the Blue Clays.	} Purple or 'Brindled' Goods. White Goods.
Top Blue Clay " " " "	
White Silica Clay [3] " " " "	
Black Clay " " " "	
	White Rock.
	Blue Clay.
	White Rock.

The raw materials are sorted in the pit after a short period of weathering, and then blended and ground in pans under edge

runners and passed through two or three pairs of rollers. They are afterwards mixed thoroughly with the requisite amount of water in the 'treading' for from 1 to $1\frac{1}{2}$ hours.

Blocks for hot acids are made from mixtures of White Rock and Blue Clay, and acid-resisting bricks from Blue Clay, or a mixture of Blue and Black Clays. Some material is made to resist both fire and acid.

Broken firebrick is used for grog, the proportions being about 1 in 6. The purple clay has small siliceous patches, which act as a kind of grog at all times.

BUCKLEY BRICK & TILE CO., LTD.

Buckley, Chester.

Brookhill Works and Quarry.

Location: Situated on western side of mineral railway $\frac{5}{8}$ mile N.N.W. of Buckley Church.

Maps: One-inch New Ser. Ordnance 108, Old Ser. Geological 79 S.E.; six-inch Flint. 14 N.W.

Latitude $53^{\circ} 10' 55''$. Longitude $3^{\circ} 4' 45''$.

Geological formation: Middle Coal Measures.

The quarry is situated between the adjacent Ewloe (or Trap) Pit on the south, and the Ewloe Barn Pit on the north.

Section of north-eastern side of pit, according to Mr. R. M. Gibson:—

	Ft.
Brown bastard rock [clayey sandstone]	18
Top Blue Clay	6-10
White Silica-rock	3
Bottom Blue Clay	12
Black Clay	8-10
Thin coal-seam	—

The beds dip eastward at about 12° , and compare closely with those worked in the Ewloe or Trap Pit (p. 171), but the Bottom Blue Clay varies from a strong to a weak variety, as at Ewloe Barn (p. 175).

Reserves: The beds are worked northwards along the strike, in which direction there are reserves for many years. The unfortunate location of the factory upon the 'dip' side of the quarry prevents development in this direction.

Mode of working: The beds are worked like those in the Ewloe Pit. There is little or no waste.

Treatment: Ordinary brindled or blue Buckley firebricks are made of mixtures of two-thirds brown rock and one-third Blue Clay, but in the large blocks these proportions are reversed. White bricks are made from the Black Clay. The White Silica-rock is added in small proportions to raise the silica-percentage.

Little time is permitted for weathering, as the clays are used up as quickly as they can be dug.

Acid-resisting goods (which will also stand fire), termed 'Metallic,' form the chief part of the output. Fire-resisting goods are the 'brindled' ('Gibsonite') or white varieties.

CHARLES DAVISON & Co., LTD.

Ewloe Barn, Ewloe, Chester.

Ewloe Barn Works and Quarry.

Location: Situated on south side of the Hawarden-Mold road about $2\frac{1}{2}$ miles west of Hawarden.

Maps: One-inch New Ser. Ordnance 108, Old Ser. Geological 79 S.E.; six-inch Flint. 14 N.W.

Latitude $53^{\circ} 11' 15''$. Longitude $3^{\circ} 4' 50''$.

Geological formation: Middle Coal Measures.

The face of the section runs north-north-west and south-south-east, parallel to the strike of the beds, then turns due west across the strike. At the north end of the section the beds dip north-east; at the south end the dip is E. at 10° - 14° .

Section at south end of quarry, 1916. [Thicknesses estimated by Mr. Hurlbutt.]

	Ft.
Soil, cleared away	—
1. Yellow rock (sandstone)	3
2. Dull purple and grey clay	3
3. Yellow sandstone	12
4. 'Blue' [purple] clay about	20
5. Black Clay from 6 ins. to	9
6. 'Warrant,' chiefly grey over	12
Over	59

The beds above the 'blue' clay are similar to those described under Ewloe Quarry (Catherall's, p. 171).

The top of the 'blue' clay is said to be of little use by itself for making firebrick; it is perhaps not so siliceous as usual. At outcrop the Blue Clay is a 'loose' clay (probably due to absence of cover), good for acid-resisting ware; it may be compared with the weak blue clay in the Castle Brickworks Quarry (p. 178). Beneath cover the 'blue' clay is more compact, and useful as an ingredient in firebricks.

The Black Clay, which forms a regular bed in the more southerly exposures, is of variable thickness and largely replaced by 'warrant' similar to that occurring in Parry's quarries to the north. There are said to be over 30 different types of material in this pit, the variations being due to chemical and mineral composition and physical structure.

Weathering is allowed to proceed as long as possible, but little time can be permitted now because the material is required for immediate use. The grey warrant deteriorates on weathering.

The fireclays were originally worked down dip, but are now chiefly won along the strike towards the south. The beds above the Blue Clays are usually brought down by undermining, those below are removed layer by layer in the direction of outcrop. There are no faults, and water is easily dealt with, but there is considerable waste from the highest beds and the warrant.

Reserves: The beds are now being worked along the strike towards the south, in which direction about 8 acres are available. The situation of the works is unfortunate, since they prevent

working along the strike towards the north. On the east the boundaries of the property are nearly reached. In this direction the dip of the beds would make heavy cover, and water might give trouble. On the west the beds are lost at outcrop. On the north-west there is a worked-out pit.

The blue and white firebricks made here are termed 'Davison' brand. In appearance the acid-resisting goods look exactly like the fire-proof goods, but have strikingly different properties (density, porosity, crushing strength, etc.). In colour they are both reddish-blue, like rusty iron.

Treatment: The rocks are selected for the various purposes required, the blends being determined by a continuous series of experiments rendered necessary by the ever-changing character of the deposits.

In the works, dry grinding pans, rollers and tempering pugs are employed, as well as the 'treading' (p. 170).

Broken firebrick is sometimes used for grog (acid brick is far too tough), but enough siliceous material is usually found in the pit to render much grog unnecessary.

The chief output from the works consists of acid-resisting goods. The brand registered as 'Obsidianite' is both acid- and fire-proof, and is used in the construction of Glover and Gay-Lussac towers, etc., and in electrolytic and chemical works.

Fire-resisting goods are termed 'Adamantine,' and are made from blends of raw material such as the yellow sandstone, purple clay beneath cover, black clay and selected warrant, and some siliceous beds in the purple clay.

EDWARD PARRY & SONS, LTD.

Buckley, Chester.

Parry's Brickworks and Quarry.

Location: Situated on the north side of the Hawarden-Mold road, about $2\frac{3}{4}$ miles west of Hawarden.

Maps: One-inch New Ser. Ordnance 108, Old Ser. Geological 79 S.E.; six-inch Flint. 14 N.W.

Latitude $53^{\circ} 11' 20''$. Longitude $3^{\circ} 5' 0''$.

Geological formation: Middle Coal Measures.

The main quarry extends in a north and south direction, with the principal working-face on the eastern side, and the beds dip E. at 15° . A smaller quarry lies to the south-west of the other.

General section in main quarry.

		[Thickness estimated by Mr. Parry.]	Ft.
East of N.-S. Fault	{	Purple and white clunch (to north)	—
		Silica-rock (quartzose sandstone)	0-2
		Soft green shale (silty sandstone and sandy marl, laminated)	10
		Deep-purple shale	3
		White or yellowish-grey sandstone, with hard top.	30
		Blue Clay { Blue-green, siliceous (6-7 ft. maximum) } 	

A fault, ranging nearly north and south, with a throw of about 20 ft., traverses the whole length of the quarry, and separates the lower from the higher beds. Part of the working-face is slickensided, indicating a movement with a southerly shift and eastward downthrow. The small quarry is situated just to the west of this fault.

In the main quarry the white sandstone forms a prominent shelf. The greater part is a bastard sandstone, which weathers down easily to a plastic material, especially when it is clayey or shaly. At the top, however, about 5 ft. of the rock is tough and quartzitic, and occasionally some greenish-grey clay is found beneath it. Sphaerosiderite is found here and there.

At the north end of the quarry a siliceous rock (better developed at the Castle Brickworks) caps the section, and rests upon a thin layer of greenish-blue micaceous shale that forms the top of the soft shale.

An impersistent greenish fireclay of variable thickness occurs at the top of the purple clay, and patches of similar material are developed sporadically at a slightly lower level. A bed of white rock (siliceous clay) appears here and there about 6 ft. below the top of the purple clay, and may be the equivalent of the 'White Rock' of Catherall's quarry (p. 171).

The greater part of the black clay of Catherall's quarry is replaced by warrants, of which the grey type is a laminated sandy silt, sometimes with glossy bedding-planes and a little sphaerosiderite. The red warrant is nodular and less laminated, and blotched with patches of green or grey colour. It is fairly siliceous.

In the smaller quarry the 'blue' clay is nearer the surface, and therefore its lower parts are available.

The beds all show signs of variation, and probably as many different types of raw material could be found as occur at Ewloe Barn.

Reserves: The property extends about 200 yards to the east, in which direction an area of about 5 acres is considered available. Owing to the dip some of the lower beds may become difficult to work from water and increasing cover. Towards the west the warrants run out at the surface, but there is still much to be got. In the smaller quarry there is a little reserve of Blue Clay. On the south further work is prevented by the position of the brickworks; whilst on the north the quarry of the Castle brickworks is almost touched.

Mode of working: The quarry is worked like those at Ewloe and Ewloe Barn. Water used to cause trouble but is now under control. There is some waste from the highest beds and from the hard top of the sandstone.

Treatment: The rock is weathered as long as possible, when much of the sandstone and the siliceous part of the Blue Clay become plastic. Physical changes at this stage are considered important.

The clay is ground beneath edge-runners in perforated pans with $\frac{1}{2}$ to $\frac{3}{4}$ in. holes, and then passed through small rollers. It next goes to the treading (p. 170).

Fire-resisting goods are made from blends of the Blue Clay with the sandstone and the siliceous top of the Blue Clay. A little warrant is added at times for hardening purposes. White firebrick is made from the black clay. The greater part of the 'blue' clay is used for making acid-resisting goods. Paving and blue ridge-tiles are made from a mixture of the soft shale with purple clay, and flooring-tiles from mixtures of black clay and warrant.

Fire-resisting goods bear the brand 'Dragon.'

CASTLE FIREBRICK CO., LTD.

Northop, Flintshire.

Castle Firebrick Works and Quarry.

Location: Situated $1\frac{1}{2}$ miles due west of Ewloe Green, and a little over $2\frac{1}{2}$ miles from Hawarden Station, G.C.R.

Maps: One-inch New Ser. Ordnance 108, Old Ser. Geological 79 S.E.; six-inch Flint. 14 N.W.

Latitude $53^{\circ} 11' 30''$. Longitude $3^{\circ} 5' 10''$.

Geological formation: Middle Coal Measures.

The quarry runs from north to south, with its steepest face to the east, and the beds dip E. at 10° to 15° .

General section, 1916. [Thicknesses estimated by Mr. Alletson]:—

	Ft.
Soil	1- 4
Purple shale [clunch]	1- 5
Silica-rock (sandstone)	3- 6
Green shale, weathering yellow	12-15
Purple shale	3
Shaly sandstone	16
White [bluish-green] Clay	10
Strong 'blue' [purple] clay, and weak 'blue' clay near outcrop (0-6 ft.)	15
White silica-stone, or black stony clay or coaly shale	0- 3
Red warrant	6- 8
Grey warrant	25
	<hr/> 110

The sequence of beds is similar to that in Parry's Pit (p. 176). The great variations in the thickness of individual beds are probably more apparent than real, and due chiefly to errors in estimation. It must be noted, however, that differences in thickness actually take place rather rapidly. There are variations in all the beds, but the greatest changes occur on the horizon of the 'weak' blue, the white silica-stone, and the black clay, each of which may be absent. At one place a little black clay is associated with the white silica-stone, but in other places, apparently, it is absent. The 'weak' blue clay occurs chiefly at outcrop.

A longitudinal fault with a downthrow east of about 20 ft. occurs at the north end of the quarry, west of the incline to the

works, and, passing southward, appears to split into two branches, which embrace between them a triangular upthrown wedge of rock. The western branch has a throw of about 6 ft.; the eastern of about 10–12 ft. In Parry's Pit the latter appears again, its throw having increased to 20 ft.; the other has not been detected.

Between these two faults, and just east of the eastern fault, the dip is east at about 15° ; elsewhere it is nearer 10° .

The top silica-rock of Parry's quarry thickens northward and is well developed in the north-east face of this quarry, where it is broken across by a small transverse fault. It is of poorer quality than the lower white silica-stone, which occurs only in the southern half of the quarry in a disturbed and slickensided state, owing to the above-mentioned faults. The white silica-stone is not found in Parry's quarry and must therefore be lenticular; but it appears to be exposed again—with the 'blue' clay—in the bed of Altami Brook about 350 yards south-west of the works. The rock exposed in a small wood about 200 yards west of the works, near Altami Brook, is probably the top silica-rock.¹

Reserves: There is a large reserve of clay in the direction of the dip, but there will be increasing cover above the 'blue' clay, and water may give trouble. No faults are known of in this direction. The property extends as far as the mineral line, a distance of about 200 yards. Workings are limited on the south by Parry's pit and on the north by the works. On the west the beds crop out, but are thrown in again by one or more longitudinal faults, throwing down west, and are exposed again in and near Altami Brook, about 200 yards west of the quarry. If there is more than one fault the beds might be brought near the surface in some of the area between the quarry and the brook.

Mode of working: The beds are worked in a similar way to those quarried farther south, the white silica-stone and underlying beds being stripped off the bared dip-slope made by blasting and undermining the higher beds. Faults are not great obstacles, and water gives little trouble except in winter.

Treatment: The raw materials are selected in the pit after little or no weathering. The rocks are crushed by three pairs of heavy rollers (one octagonal, two smooth) to a gauge varying from $\frac{1}{16}$ in. to $\frac{3}{8}$ in., and the material is carried by elevators to a room whence it is distributed by shoots to tempering-pugs. The 'treading' (p. 170) is not employed here.

Firebricks are usually hand-made, but some dense wire-cut bricks are made for foundations in steel-works.

The silica-rocks are used for making silica-brick, and a new plant has been installed to deal with them.

From the other beds fire-bricks and acid-resisting goods are manufactured, of similar types to those made elsewhere in the Buckley district.

The fire-resisting goods comprise 'C.S.' Blue Fire-bricks and 'S.S.' White Fire-bricks.

¹ Special Reports Mineral Resources, vol. vi., Ganister and Silica Rock etc. (*Mem. Geol. Surv.*), Ed. 2, 1920, p. 118.

WILLIAM HANCOCK & Co. (HAWARDEN), LTD.

Buckley, Chester.

Lane End Brick Works and Quarry.

Location: Situated at Lane End, $\frac{1}{2}$ mile S.S.E. of Buckley Church. The Knowl Hill Brick Works (late R. Ashton & Co.) are incorporated with Messrs. Hancock's.

Maps: One-inch New Ser. Ordnance 108, Old Ser. Geological 79 S.E.; six-inch Flint 14 N.W.

Latitude $53^{\circ} 10' 5''$. Longitude $3^{\circ} 4' 0''$.

Geological formation: Middle Coal Measures.

The thicknesses of the beds in the following section, taken about the middle of the north-eastern side of the Lane End Quarry, were estimated by Mr. Prince:—

	Ft.
Rubble (waste)	4
Buckley fireclay	30
Hard yellow grit (waste)	15
'Silica rock'	30
Blue Clay	24
Black Clay	3

The section is continued as follows, in the south-western part of the quarry:—

	Ft.
Black Clay (continued)	12
Smudge (black shale and coaly matter)	—
Warrant, containing ironstone-nodules	—
Hollin Coal	—

The beds dip N. 20° E., and the clays vary from point to point in the usual way.

All the beds in the quarry-face, except those marked 'waste,' are utilized.

Reserves: The reserves of clay, in the direction of dip, are large.

Mode of working. The beds are worked by driving shallow dip-headings for a few feet into the Blue or the Black Clay at intervals. The separating pillars are then blown out and the face falls. Large rock-masses among the debris are then broken by explosives. Water gives little trouble.

Both this and the Mount Pleasant Pit have been worked up to the eastern boundary fault, which is exposed also in the old Ewloe Pit.

Treatment: The clays are not weathered; they are sorted and ground under edge-runners, passed between rollers, blended and pugged with water, and hand-moulded. The grog used consists of ground waste brick, both blue and white.

The wares produced consist chiefly of acid-resisting goods made mainly from the outcrop portion of the Blue fireclay (*cf.* weak 'blue' clay, pp. 169, 170).

The firebricks produced are of two types: (1), Blue or 'brindled,' made from mixtures of fireclay and silica-rock, with a crushing-strength of 300 tons to the square foot, and (2), White, made chiefly from the black clay.

The firebricks are used as building-bricks also, especially in the construction of railway stations and bridges.

White firebricks are employed in furnaces where continuous heat is applied. Firebricks and bricks for bolt works are made of Black Clay.

WILLIAM HANCOCK & CO. (HAWARDEN), LTD.

Buckley, Chester.

Mount Pleasant Brick Works and Quarry.

Location: Situated about 300 yards S.E. of Buckley Church.

Maps: One-inch New Ser. Ordnance 108, Old Ser. Geological 79 S.E.; six-inch Flint. 14 N.W.

Latitude $53^{\circ} 10' 20''$. Longitude $3^{\circ} 4' 0''$.

Geological formation: Middle Coal Measures.

The section of Buckley clays exposed here is intermediate in type between that of the Lane End and Old Ewloe Quarries. The dip of the beds varies between E. and S.E. at 6° . A thin coal, similar to that occurring at Old Ewloe, appears in the black clay in the floor of the quarry.

Goods similar to those produced by the Lane End Brick Works are manufactured here.

CHARLES DAVISON & CO., LTD.

Ewloe Barn, Ewloe, near Chester.

Old Ewloe Works and Quarries (and Etna Clays).

Location: Situated about $\frac{1}{2}$ mile N.N.E. of Buckley Church and $1\frac{1}{2}$ miles N.W. of Buckley Junction (G.C.R.).

Maps: One-inch New Ser. Ordnance 108, Old Ser. Geological 79 S.E.; six-inch Flint. 14 N.W.

Latitude $53^{\circ} 10' 40''$. Longitude $3^{\circ} 4' 5''$.

Geological formation: Middle Coal Measures.

The large pit south of the works is practically worked out, the section being somewhat similar to that of the Mount Pleasant Quarry (Hancock's), in which all the beds are exposed. The black clay contains a thin coal-seam, lying from 6 ins. to 3 yards below its top. It contains balls of ironstone also, about as large as the closed fist.

In this pit there are three Blue Clays, separated by White Rock; but the section is obscure. A new pit has been opened at the north-west end, west of the works.

Section in New Pit, Old Ewloe. [Thicknesses estimated by Mr. Hurlbutt]:—

	Ft.
Soil, etc.	—
Top rock	12
Blue or ' Ridge ' Clay (with strong top, about 5 ft.) ...	12
White Rock	15
Blue Clay (bastard)	6-8
Black Clay	4
over	51
	—

At this point the beds dip N.N.E. (towards the Old Etna Pits) at 14° . In the old Ewloe Quarry the dip is E. 15° S. at about 13° . The old quarry has been worked eastward to the boundary fault, which has brought to the surface older beds with workable coals.

The beds are as variable as usual. The White Rock of the old pit is said to contain 95 per cent. of silica.

Reserves: These lie chiefly to the north, where reserves of the clays formerly worked at the Globe and Etna Brick Works are available, and will last for many years. These old brickworks, situated on the outcrop, have been dismantled to clear this ground. The old pit is limited on the east by the boundary fault; on the south by other property, and on the west by the outcropping of the beds.

Mode of working: In the new pit the work will be carried northward along the strike towards the Etna property, avoiding the Ewloe Brick Works, which, unfortunately, stand upon useful ground. There is a good deal of waste from unsuitable beds.

Water causes trouble when the workings are deep. A wind-mill pump cannot cope with it in wet seasons.

The raw materials are used for the same purposes as at Ewloe Barn.

Denbighshire.

In the coal-bearing series of Denbighshire only a few of the fireclays, which occur quite as frequently as they do in all coal-fields, are worked for refractory purposes.

The Middle and Lower Coal Measures of Denbighshire, as a whole, dip eastward off the Cefn-y-fedw Sandstone ('Millstone Grit,') and the coalfield is cut up by numerous faults, of which the longitudinal are the more important. On the eastern side, in the concealed part of the field, these faults tend to counteract the eastward dip, and keep the measures near the surface.

The fireclay seams at present raised (both as refractory and pottery clays), and the localities where they are used, are shown in the following table, which gives the position of the chief coal-seams below the Main Coal as proved in the shafts of the Wynn-stay Colliery, Ruabon, where the best seams are worked.

COAL-SEAMS.	FIRECLAYS.				
	Delph, Ruabon.	Smelt, near Brymbo.	Coppice, Rhôs. ¹	Erwlwyd, Rhôs. ¹	Garth, Trevor.
Main Coal
Brassy Coal
Upper Yard Coal
Red Coal
Stone Coal
Half-Yard Coal
Benches Coal
Firedamp Coal
Coal
Coal
Nant Coal
Lower Yard Coal
Wall and Bench Coal
Llwyneinion Half-Yard Coal
Chwarele Coal

¹ Abbreviation for Rhôsllanerchrugog.

Fire-resisting goods in increasing quantities are made from the Stone, Half-Yard and Llwyneinion Half-Yard fireclays, whilst the fireclay beneath the Chwarele Coal is used for making ganister compound. The lower clays at Delph and the Llwyneinion Half-Yard Clay, however, are chiefly employed for making glazed ware, sanitary pipes and so-called artificial stone, or terra-cotta ware with 'stone' facing.

In the district including Trevor, Rhôsllanerchrugog, and Llwyneinion near Ruabon, there is a large reserve of the Llwyneinion Half-Yard and Chwarele clays.

Many of the unworked fireclays in the measures underlying the Main Coal in the Denbighshire area might be suitable for refractory purposes, but would require trial; some of these are referred to in the detailed accounts that follow.

The Stone and Half-Yard fireclays have been worked at outcrop at Acrefair and Rhôsllanerchrugog.

WYNDHAM & PHILLIPS, LTD.

Ruabon.

Delph Pits and Works.

Location: Works and shafts situated about $\frac{3}{4}$ mile N. of Acrefair Station (G.W.R. Llangollen Branch).

Maps: One-inch New Ser. Ordnance 121, Old Ser. Geological 74 N.E.; six-inch Denbigh 35 S.W.

Latitude $52^{\circ} 59' 15''$. Longitude $3^{\circ} 4' 20''$.

Geological formation: Middle and Lower Coal Measures.

Both fireclays and coals are won from two winding-shafts, Nos. 2 and 5. No. 2 shaft is situated almost on the outcrop of the Brassy Coal, and No. 5 a few yards farther east, starting in higher measures.

The positions of the fireclays in No. 5 Shaft are shown in the following section:—

	Thickness.		Depth from bank-top.	
	Ft.	In.	Yds.	Ft. In.
Measures	177	1	—	—
Stone Coal	12	4	—	—
FIRECLAY 'A'	1	0	—	—
Half-Yard Coal	1	6	—	—
FIRECLAY 'B'	3	6	—	—
Fireclay Coal	1	7	62	1 0
Fireclay with small ironstone-nodules	21	2	—	—
Measures				
FIRECLAY 'C'	3	6	—	—
Coal	0	3	—	—
FIRECLAY 'D'	2	10	71	1 9
Measures	21	3	—	—
FIRECLAY 'E'	4	0	80	0 0
Measures	27	0	—	—
Nant Coal	6	0	91	0 0

Still lower, a fireclay 'F' occurs beneath the Lower Yard Coal.

Towards the north-west the fireclay 'B' increases to about 6 ft. in thickness.

The general direction of dip is between E.S.E. and S.E. At the surface it measures 15° , but underground it is 8° (1 in 7) in the Half-Yard Coal. The Stone and Yard Coals crop out about 350 yards west of No. 2 Shaft.

Fireclays 'A' and 'B' are said to be of fairly uniform character, and from light-grey to dark-grey in tint. Although mildest, the Half-Yard Clay is palest, and burns almost white.

Reserves: Limited by outcrop. There is said to be sufficient for 15-20 years to come since the artificial boundaries of the property have not yet been reached. The lower clays 'E' and 'F' are practically untouched, but the first is now being tried for pottery in order to release more of the higher clays for fire-bricks. Reserves at the pit-head are becoming exhausted, owing to lack of labour.

Mode of working: The beds are worked by pillar-and-stall, both up and down-dip from the shafts, and the workings have been diverted north-westward by water, which at present gives trouble only when old workings, such as those in the Stone Coal, are near. These old workings have reduced the fireclay 'A' to a thickness of 9 in. in places, making a bad roof to the underlying seams. Where 'B' is thickest the coals must be left as roof and floor, and can be removed at a late stage only.

Treatment: The fireclay is weathered as long as possible at the pit-head (some of 'B' for 5 years). It is ground, mixed with grog or silica sand, and passed through two horizontal pugs to wire cutters. In future, hand-made bricks will probably be manufactured. A separate mill makes cement or 'fireclay' paste.

The two upper fireclays, 'A' and 'B,' are blended and made into firebricks, boiler seating-blocks, flue-covers, tiles and domestic goods.

The clays 'C,' 'D' and 'E,' mixed with some of the upper clays, are made up into sanitary pipes, etc., and occasionally pots for picric acid.

J. & C. EDWARDS.

Tref-y-nant Works, Trevor.

Coppice Pit and Works and Tref-y-nant Works.

Location: Shafts situated at Coppice Works, N. of Rhôsllanerchrugog Station, G.W.R. Tref-y-nant Works situated $\frac{1}{4}$ mile N.E. of Trevor Station.

Maps: One-inch New Ser. Ordnance 121, Old Ser. Geological 74 N.E.; six-inch Denbigh 35 N.W.

Latitude $53^{\circ} 0' 45''$. Longitude $3^{\circ} 3' 40''$.

Geological formation: Middle and Lower Coal Measures.

The seam of fireclay underlies the Llwyneinion Half-Yard Coal, and is the same as that worked at Pant (p. 186); its position in the geological sequence is given on p. 182.

At the winding-shaft the depths from the pit-bank to the various seams mined are as follows:—Nant Coal 23 yards, Yard Coal 33 yards, Wall and Bench Coal 50 yards. From the latter

there is a horizontal cross-measure drift driven westward to the rise to cross an upthrow fault that brings in the Llwyneinion Half-Yard Coal and fireclay at this level, the general dip being eastward.

The seam occurs about 20 yards below the Wall-and-Bench Coal, and an average section gives 1 ft. 4 in. of coal on 3 ft. of fireclay which merges downwards into a hard gritty stone.

In the distant parts of the mine a section of the fireclay shows about 1 ft. of black clay on 1 ft. 6 in. of blue clay, but changes occur in the direction of the shaft to which the work is being carried back.

The seam there consists of:—

Black flaky clay [cross-bedded shale]	{ Used for firebrick and enamelled goods. }	4
Black clay with plant-remains ...		
Grey clay	{ Used for buff bricks }	3
Blue clay.... ..		

Reserves: The available fireclay in the present working-belt covers 35 acres. There is also a further spread of about 20 acres in the property, part of which, however, will be under water. A considerable area of this seam exists outside of, and adjacent to, this property.

Farther south the seam crops out between Pen-y-bryn and Trevor Station, and has been worked at a shallow depth at the Tref-y-nant Works, north of which there is a large unworked tract of ground.

Both the Yard and the Wall-and-Bench Coals have a fireclay floor, and might be worked in the southern area. Near Rhôs, however, the fireclays have been mutilated in extracting the coal in former years.

The fireclays, and also the silica-rock associated with the Chwarele Coal, are intact, except for outcrop-workings, and await development.

Mode of working: Working is by the pillar-and-stall method.

Treatment: Weathering takes place at the most for six months (owing to lack of labour and consequent shortage of surface reserves) and the clay is then removed to the mills and subjected to the usual processes of grinding. Broken brick or sagger is used for grog, and some white Ffrith stone¹ is added to raise the silica-percentage.

Firebricks are wire-cut but not pressed, and are dried on steam-heated floors and fired at a temperature of about 1200° C. in downdraught kilns. The bricks are of a yellowish-buff colour, a tint requiring excess of oxygen during firing, otherwise they would be too pale.

The clay is used chiefly for making pottery, artificial stone, tiles and so on; but firebricks, flue-linings, chimney-pots (saggers for own use), etc., also are made.

Note. Since the date of our visit firebricks have been made in dry-press machines. The clay is ground, grog or silica-stone is added, and the mixture damped and pressed. These bricks must

¹ 'Mineral Resources of Great Britain,' vol. vi. Ganister and Silica Rock (*Mem. Geol. Surv.*), 2nd edit., 1920, p. 117.

be fired for twice the time required for the plastic bricks. They are said to soften at about 1700° C. The fireclay used is from the same horizon as that mined at the Smelt Pit (below), and is raised at a pit a short distance south of Coed Poeth station near Minera.

THE RUABON COAL & COKE CO., LTD.

Ruabon.

Erwlwyd Pit and Pant Brickworks.

Location: Shaft situated about $\frac{1}{2}$ mile S.W. of Rhôsllanerchrugog Schools; works $\frac{1}{4}$ mile S.E. of pit.

Maps: One-inch New Ser. Ordnance 121, Old Ser. Geological 74 N.E.; six-inch Denbigh 35 N.W.

Latitude $53^{\circ} 0' 30''$. Longitude $3^{\circ} 4' 1''$.

Geological formation: Middle and Lower Coal Measures.

The Llwyneinion Half-Yard fireclay mined at this spot is the southward continuation of the seam worked at the Coppice Pits (p. 184). It occurs at a depth of 150 ft. from the surface, and the general dip is eastward.

An average section of the fireclay seam, which is about 3 ft. in thickness, consists of black-purple clay overlying greyish or greenish-blue clay.

The fireclay contains small ironstone nodules, and formerly used to be selected for various purposes, the upper dark purple clay being preferred for making fire-resisting goods, and the lower grey and blue clay for glazed and sanitary goods, which in normal times form the main output of the firm.

Reserves: A reserve of about 4,000 tons of clay, sufficient for several years, is stored at the brickworks. None was being added to the store at the time of our visit.

Treatment: The clay is subjected to the usual processes of grinding and mixing. Firebricks are hand-moulded (or wire-cut if desired). Burnt clay and old bricks are used for grog, and quartzite siftings from Bwlchgwyn¹ are employed for sanding the moulds. The bricks are of a buff tint, and are suitable if placed in positions where great heat is not expected. In addition to glazed ware, flooring-tiles also are made of fireclay.

THE BRYMBO STEEL CO., LTD.

Brymbo, Wrexham.

Smelt Pit and Caello Brickworks.

Location: Shaft situated $\frac{3}{4}$ mile N.W. of Brymbo Station. Brickworks nearly $\frac{1}{2}$ mile N.E. of shaft.

Maps: One-inch New Ser. Ordnance 121, Old Ser. Geological 74 N.E.; Shaft: six-inch Denbigh 28 N.W.; Works, 21 S.W.

Latitude $53^{\circ} 4' 40''$. Longitude $3^{\circ} 4' 10''$.

¹ 'Mineral Resources of Great Britain,' vol. vi, Ganister and Silica Rock, etc. *Mem. Geol. Surv.*, Ed. 2, 1920, p. 108.

Geological formation: Middle and Lower Coal Measures.

In the following section of the Smelt Pit the position of the fireclay is indicated, the dip being eastward at 8° (1 in 7).

	Thickness.		Depth from surface.	
	Ft.	In.	Yds.	Ft. In.
To bottom benches of Main Coal...	51	9	17	0 9
Shale, clunch and ironstone	5	0	—	—
Coal	0	6	19	0 3
Measures	36	3	—	—
Yard Coal	2	11	32	0 5
Clunch	9	0	—	—
Measures	40	10	—	—
Red Coal	1	8	49	0 11
Clunch	4	0	—	—
Measures	53	8	—	—
Black Stone	0	8	68	2 3
Coal, 1 ft. 6 in.	10	10	72	1 7
FIRECLAY, 3 ft. 6 in.				
Coal, 6 in.				
FIRECLAY, 4 ft. 4 in.				
Coal, 1 ft.	5	0	80	1 3
Clunch				
Measures				
Fireclay				
Black Clunch	0	5	—	—
Nant Coal, or 4-Foot	3	8	81	2 4
Fireclay	3	0	—	—
Measures with Wall-and-Bench Coal, two other coals, and the Queen or Wallsend Coal	159	4	—	—
Cefn-y-fedw Sandstone	15	0	140	2 8

This fireclay is apparently the same as that beneath the Stone Coal at Delph, near Ruabon (p. 183). but the clunch underlying the lower coal [? Half-Yard] is not worked as a fireclay here. The clay is darkest at the bottom of the seam, but it suffers considerable variation in a horizontal direction. Occasional patches are too siliceous and are therefore discarded.

Reserves: Reserves are ample. The pit is situated west of a 25-yard fault, down east, with a north-and-south trend, which throws in the sandstones above the Main Coal. Another fault, down west, is situated about 250 yards west of the shaft. If necessary the clay could be got beyond each of these faults. There is a large reserve in the surface tips. In addition there is the Yard fireclay and others in the mine that might be exploited.

At the firm's Brymbo pit the fireclay in reserve beneath the Drowsel Coal is said to analyse like the Caello clay, but to be of a more fatty nature.

Mode of working: The mine is worked by pillar-and-stall, a method necessitated by the occurrence of overhead buildings.

Mode of treatment: The clay is weathered for at least 6 months, after which it is made up in the usual way. Firebricks are wire-cut from a side-delivery pug, but some are made by hand. Stoppers, nozzles and sleeve-blocks are machine-made and hand-finished. Broken firebrick is used for grog, but sand from Ffrith and from Bwlchgwyn also is added to the raw clay.

LLAY HALL BRICK COMPANY.

Llay Hall, near Wrexham.

Situation : Llay Bank level on the east bank of the River Alyn, 150 yards E.N.E. of Llay Hall Colliery Shafts.

Maps : One-inch New Ser. Ordnance 121, Old Ser. Geological 74 N.E.; six-inch Denbigh 21 S.E.

(Level) Latitude $53^{\circ} 5' 22''$. Longitude $3^{\circ} 1' 15''$.

Geological formation : Coal Measures.

The stratigraphical position of the clays is at present obscure.

The following section was measured in the level in December, 1918:—

								Ft.	In.
1.	Red Clay	...	...	...	...	...	...	2	0
2.	Soft grey clay, upper layers red-stained	...	...	...	...	...	...	4	6
3.	Soft blackish clay	...	...	...	...	...	6 in. to	1	0
4.	Hard white clay	...	...	...	...	...	...	4	6
5.	Dark grey clay, estimated thickness	...	...	...	...	...	...	7	0
6.	Hard siliceous clay...	...	...	...	...	...	...	15-20	0
7.	Dark grey clay	...	...	...	...	...	proved	2	0

The clays dip eastward at 1 in 7 and continue in this direction until they reach a fault which throws them down about 360 ft. to the east.

It is proposed to work Beds 2 and 3 as one seam of clay. Bed No. 2 contains silica 49·52, alumina 32·51, ferric oxide 3·13 per cent.; a sample tested by Dr. J. W. Mellor did not soften below Cone 33 (1730° C.). Bed No. 5 contains Silica 60·90, Alumina 25·82, ferric oxide 1·59 per cent.; it is refractory to Cone 30-31 (1670° - 1690° C.).

Reserves : The reserves of the above clays on the property are estimated at 100 acres.

Note. An 8 ft. bed of grey-brecciated clay appears in the cutting on the mineral line opposite the old Paper Mill (now Magnesite works) at Cefn-y-bedd, $\frac{3}{4}$ of a mile north-east of the level. It contains silica 70·81, alumina 19·23, ferric oxide 1·22 per cent., and the alkalis and alkaline earths are low. It is refractory up to Cone 31.

CHAPTER XV.

SOUTH WALES AND MONMOUTHSHIRE.

INTRODUCTION.

All the firebricks manufactured in South Wales and Monmouthshire are made from fireclays obtained from the Coal Measures of the district.

The Coal Measures of the South Wales coalfield are divisible lithologically as follows:—

Upper Coal Series: chiefly shales, with coals.

Pennant Series: sandstones with subordinate shales; with coals.

Lower Coal Series: chiefly shales, with coals.

The seams of coal, which throughout this district are styled 'veins,' are generally underlain each by an underclay, which forms the coal-seat, floor or thill. This clay is usually a fireclay. There are, however, several cases known of fireclays that are not associated with a coal-seam.

The fireclays in use for refractory purposes belong to the Lower Coal Series and to the Pennant Series; none in the Upper Coal Series is known to be worked.

The raising of fireclay is carried on at widely separated localities and is not concentrated in any one district. On the eastern margin of the coal-basin, in Monmouthshire, a small number of mines are worked for clay near Pontypool. On the northern margin some are situated close to Beaufort. Continuing westward, across Glamorgan, after a long interval we find others in the upper part of the Tawe or Swansea Valley about Ystalyfera, and, farther west, in Carmarthenshire, near Brynamman, Ammanford and Pontardulais. On the north-western edge of the coal-basin no fireclays appear to be raised. Coming round into the southern margin we find several firebrick works near Llanelly, and others in the lower part of the Tawe Valley near Swansea; but farther east, no fireclay mines are met with until we find one near Caerphilly and another at Risca, near Newport. In the Pembrokeshire part of the coalfield, which is separated from the eastern part by Carmarthen Bay, no fireclay is raised.

The distribution of the industry thus appears to be irregular, and dependent more on local demand for firebricks than on the local abundance or absence of specially suitable clays.

The following are the clays (in approximate descending order of position in the Coal Measure sequence) worked in the Llanelly and Swansea district:—

Pennant Series:

A clay 35 to 40 ft. below the Five-Foot Coal, at Morris-ton, near Swansea.

The Graigola (Six-Feet or Fiery) Fireclay, at Clydach, Glais and Pontardawe in the Swansea or Tawe Valley.

The Golden Rock Fireclay, at Pontardulais and Bynea, near Llanelly.

The Black Rock Fireclay, at Pwll, Llanelly.

The Gyscwrm Rider Fireclay, at Pembrey.

Lower Coal Series :

Shales some distance below the Red Coal, at Ynysci, near Ystalyfera, Tawe Valley.

A clay 30 ft. below the Red Coal at Cwmgors, near Brynamman.

The Pencraig, Little or Lower Four-Feet Fireclay, at Lower Cwmtwrch, Tawe Valley.

A clay 51 to 54 ft. below the Rocket Coal, at Pontyclerc, near Ammanford.

In Monmouthshire and East Glamorgan the following clays are raised :—

Lower Coal Series :

The Soap Fireclay, at Graigddu, near Pontnewynydd, Pontypool.

A clay about 45 ft. below the Soap Coal, at Blaendare, Pontypool.

Three clays, respectively 34 ft., 27 ft., and 21 ft. above the Elled Coal, at Ebbw Vale.

The Red Coal Fireclay, at Wernddu, near Caerphilly.

The Big Coal Fireclay, at Wernddu, near Caerphilly.

A clay 8 ft. above the Old Coal, at Beaufort, near Ebbw Vale.

The Old Coal Fireclay (in the Old Coal) in the Pontnewynydd district, near Pontypool.

The Old Coal Underclay, a so-called 'ganister,' at Trefil, near Ebbw Vale.

'No. 5 Fireclay' (position uncertain), at Darran, near Risca.

As in other districts, different methods may be seen in operation. The clay is in some places weathered before use, in others it is employed in the raw state. Bricks are made by the plastic, semi-plastic and semi-dry processes; some hand-made bricks are produced, but the majority are machine-pressed. Some manufacturers make a wire-cut brick and do not press it, others press and brand the brick.

The most common type of kiln is the round one with draught firing. Occasionally rectangular draught kilns are met with but only as accessories to the round ones. Several firms, especially those whose output is in red building brick, burn their firebricks in continuous kilns of the Hoffmann type; other continuous kilns in use are a 'modified Belgian' kiln, the 'Ormond,' and the 'Staffordshire' kiln.

The state of the firing is judged by trial bricks, by inspection of the interior of the kiln through peepholes at top or at bottom, by the experience and practice of the burners, and in continuous

kilns by the total vertical shrinkage of the pile, which should amount to $\frac{3}{4}$ in. to 1 in. per foot. Two firms use Seger-cones for downdraught kilns, and one firm occasionally uses a pyrometer.

The refractory products embrace the usual shapes of firebrick, sleeves, stoppers, nozzles, tuyeres, etc. Vitrified brindled acid-resisting bricks are also made. Ground clay and ground shale are produced for lining ladles and similar purposes.

Monmouthshire.

SOUTHWOOD, JONES & Co., LTD.

Danygraig Works, Risca, Mon.

Works: Situated at (1) Danygraig, Risca; (2) Graigddu, Cwmnant-ddu, $1\frac{1}{4}$ mile W. of Pontnewynydd, near Pontypool.

Mines: Fireclay is obtained from (1) Graigddu Level, on north side of Cwmnant-ddu, adjacent to the Graigddu Works; (2) sundry local fireclay-mines, to the extent of 10 per cent. to 15 per cent. of the total fireclay used.

Maps: One-inch New Ser. Ordnance and Geological 232; six-inch Mon. 18 S.W.

Graigddu Level: Latitude $51^{\circ} 42' 45''$. Longitude $3^{\circ} 4' 55''$.

Geological formation: Coal Measures. Lower Coal Series. Fireclay under the Graigddu (supposed Soap) Coal.

1. *Graigddu Level and Works.*

The section is as follows:—

						Ft.	In.
Black rashings	...	...	...	...		4	0
Coal, 1 ft. 4 in.	}	Scap Coal	...	...	...	2	11
Shale, 11 in.							
Coal, 8 in.							
FIRECLAY (working), 8 ft. to			...	...	...	9	0

The upper half of the fireclay is a little darker and softer than the lower half, while the topmost layers are the darkest. The coal itself being thin is left to support the roof.

Reserves: The seam dips west at 4 or $4\frac{1}{2}$ in. to the yard. A fault has been met with towards the north-east. There are large reserves to the north-west.

Method of working: By pillar-and-stall. The mine is drained by the level. Small nodules of detrimental matter are picked out underground and on the dumps. The different grades of the clay are not separated. After weathering for about six months it is ground dry under edge-runners and passes through the usual processes. Some 'grog' in the form of old burnt firebricks is added to the fireclay while at the grinding-mill.

2. *Danygraig Works.*

At these works some common firebricks are made from local clays of lower grade than the Graigddu Clay; but the main output consists of best-quality fireclay goods made from the Graigddu Clay brought by rail from the Graigddu Level. Firebricks and blocks of the standard forms and sizes are made, including coke-oven and oil-furnace bricks.

Ground calcined fireclay is supplied to the zinc-smelters, and ground raw clay also is sold.

DARRAN FIREBRICK WORKS CO.

BRANCH OF THE STAR BRICK AND TILE CO., LTD.

Darran Works, Risca, Mon.

Works and Mine: Works situated $\frac{3}{4}$ mile N.W. of Risca Station (G.W.R.). Clay-level, known as the Darran Slant, about $\frac{1}{4}$ mile north of the works.

Maps: One-inch New Ser. Ordnance and Geological 249; six-inch Mon. 28 N.W.

Latitude $51^{\circ} 37' 17''$. Longitude $3^{\circ} 6' 23''$.

Geological formation: Coal Measures, Lower Coal Series.

The fireclay worked, which is known as 'No. 5 Fireclay,' is about 6 ft. thick, of which the upper 3 ft. is 'best quality' and the lower half 'second quality.' These are separated by a parting, 2 to 5 in. thick, of rashings or shales, which are rejected. The two grades of clay are separated and used respectively for best and second quality goods.

The bed dips N.W. at 3 to 9 in. in the yard, and crops out towards the south-east.

Reserves: There are large reserves of the No. 5 clay, and there are several other clays on the property, viz., those associated with the Brass, the Thick, the Grey, the Red, and the Pontymister Veins of coal, as well as the Rock Vein Clay, which is said to contain 86.42 per cent. of silica and 11.95 per cent. of alumina.

Method of working: The clay is worked by the longwall method. In normal times it is weathered several years.

THE STAR BRICK AND TILE CO., LTD.

Llantarnam, Newport, Mon.

Works: Situated at Llantarnam, 4 miles N. of Newport.

Mine: The fireclay is brought from the Lower Varteg pit belonging to the Varteg Deep Black Vein Collieries, Ltd., Varteg, near Pontypool. The colliery is 1 mile N.W. of Abersychan, near Pontypool, and about 7 miles from Llantarnam. The raw fireclay is brought to the works by rail (G.W.R.).

Maps: One-inch New Ser. Ordnance and Geological 232, six-inch Mon. 18 N.W.

(Lower Varteg.) Latitude $51^{\circ} 44' 24''$. Longitude $3^{\circ} 4' 48''$.

Geological formation: Coal Measures; Lower Coal Series. Old Coal Fireclay.

The section of the coal and fireclay is as follows:—

				Ft.
Old Coal	{	Top Coal, occasionally unworked		
		where the fireclay is mined...	...	—
		FIRECLAY (working) ...	...	3-4
		Bottom Coal (working) ...	...	2-3

The dip is west at $3\frac{1}{2}$ in. to the yard; the clay thickens towards the east, and finally crops out about a quarter of a mile east of the shafts. There are some small faults. The clay contains no detrimental matter of any importance.

Reserves: There are considerable reserves.

Method of working: The clay is worked by the longwall method. From the colliery it is conveyed by rail to the Star Works at Llantarnam, where it is weathered on the surface for two years or more. At the works, the tip, which is exceptionally large, is in some parts three or four years old.

The clay as received at the works is not further selected or blended, but is all used together. The grog added during the grinding consists of old firebricks and some calcined sandstone. This is obtained from the company's clay-pit, adjacent to the works, in which a fine section of red marls with interbedded sandstones is exposed. These marls, which belong to the Lower Old Red Sandstone, furnish the materials for the red bricks and tiles manufactured on a large scale by the company, who make sanitary pipes also.

THE OAK BRICK CO., LTD.

Pontnewynydd, near Pontypool, Mon.

Works: Situated at Cwm-nant-ddu, $\frac{1}{2}$ mile west of Pontnewynydd Station (G.W.R.).

The chief product of the works consists of red and buff bricks made from local shale, the firebrick department being subsidiary.

Mine: Fireclay is bought from Messrs. J. & W. Jones, Snatchwood Slope, Pontnewynydd, $\frac{1}{2}$ mile north of the Oak Works.

Maps: One-inch New Ser. Ordnance and Geological 232; six-inch Mon. 18 S.W.

Latitude $51^{\circ} 42' 55''$. Longitude $3^{\circ} 3' 50''$.

Geological formation: Coal Measures; Lower Coal Series. Old Coal Fireclay.

The section is as follows:—

					Ft.
		FIRECLAY (working)	...	...	6
		Top Coal (old pillars, working)	...	...	2
Old Coal	{	FIRECLAY (working)	...	...	2
		Bottom Coal (working)	...	...	2

Both beds of fireclay are got out, dumped together and carted half a mile downhill to the Oak Works.

Reserves: The slant enters ground at or near the crop of the coal and follows it down the dip, which is westward. The reserves of clay are said to be large, although of the coal itself only pillars are left from the old workings.

Mode of working: The coal and clay are got by driving narrow stalls, between which pillars are left. The top clay can be got without mixture with the coal more easily than the bottom clay, which brings down the top coal with it. Water drains away into the old coal-workings.

Treatment: At the works the clay is weathered as long as

possible; under present conditions it is used up as fast as delivered. But coming from old coal-workings it does not require so much weathering as if it were taken from the unbroached mine.

Crushed sandstone, quarried from a shallow excavation 50 to 100 yards north-west of the brickworks, is added to the clay. This is a fine-grained ganister-like sandstone containing rootlets of plants. Its geological position appears to be low in the Lower Coal Series and not far above the Millstone Grit.

Ground firebricks are used as grog in the preparation of ground fireclay.

THE BLAENDARE CO., LTD.

Blaendare Slope, Pontypool, Mon.

Works: Situated at Upper Race, 1 mile S.W. of Pontypool.

Mine: The Blaendare Slope, adjacent to the Brickworks.

Maps: One-inch New Ser. Ordnance and Geological 249; six-inch Mon. 23 N.W.

Latitude $51^{\circ} 41' 10''$. Longitude $3^{\circ} 3' 9''$.

Geological formation: Coal Measures; Lower Coal Series.

The fireclay is said to lie half-way between the Soap Vein and the New or Elled Vein, and is represented in the section of the Glyn Pit, Pontypool, published by the Geological Survey¹.

The seam presents the following section at Blaendare:—

	Ft.	In.
Blackband	—	—
Sandstone and clift, mixed	—	—
FIRECLAY (working)	5	0
Coal (not worked)	0	8
Fireclay, inferior, with ironstone nodules	—	—

The top part of the fireclay, from 0 to 1 ft. thick, is darker than the rest, and is considered to be inferior in quality and tends to produce a black spotting of the bricks. The remainder of the clay, which is of lighter colour, frequently shows red mottlings. The whole of the clay is used together, and there is practically no waste or deleterious material. The bed dips about north-west at 3 in. per yard.

Reserves: There are large reserves, both underground and in the tips. No serious faulting has been met with.

Mode of working: The clay is mined by the longwall method. The water is pumped.

Treatment: The clay is weathered on the surface as long as possible, the process being assisted by frequent spraying with cold water in summer and hot water in winter.

The ordinary firebricks are wire-cut; special bricks are hand-moulded. For hand-moulded goods the grog is kiln-dust and a little ground firebrick.

¹ Vertical Sections, Sheet 80, No. 9, 1895.

GUEST, KEEN & NETTLEFOLDS, LTD.

Cwmbran, Newport, Mon.

Henllys Firebrick Works and Viaduct Level, Pontnewynydd.

Works: Situated $\frac{1}{2}$ mile S.S.W. of Cwmbran Station (G.W.R.), 4 miles N. of Newport.

Mine: Fireclay brought from the Company's Viaduct Level at Pontnewynydd, near Pontypool ($\frac{5}{8}$ mile W. of Pontnewynydd Station).

Maps: One-inch New Ser. Ordnance and Geological 232; six-inch Mon. 18 S.W.

Latitude $51^{\circ} 42' 38''$. Longitude $3^{\circ} 3' 56''$.

Geological formation: Coal Measures; Lower Coal Series. Old Coal Fireclay.

The section is as follows:—

					Ft. In.
	Strong rock	...	...	...	—
Old Coal	{ Top coal (usually left in)	...	...	...	1 3
	{ FIRECLAY (working), 5 to 8 ft., say	...	...	...	6 0
	{ Bottom coal (working)	...	...	...	1 10
	Strong rock	...	...	...	—

The fireclay is somewhat darker towards the bottom, the dark part varying in thickness from 0 to 18 in. All the clay is used together at the firebrick works, though for special goods the best qualities are selected.

The fireclay in places passes laterally into a hard fine-grained quartzose rock, but this has not yet been made use of. For mixing with the clay it would need heavy grinding machinery, and it has not yet been ascertained that there is any considerable amount of the rock available.

Reserves: The coal and clay dip westward from the outcrop at about 3 in. per yard. About a quarter of a mile west of the Level the property is crossed by the Greenland Fault, a downthrow west of 12 to 26 yards; but there are large reserves of the clay between the fault and the outcrop. Water drains away into the old coal-workings.

Mode of working: The clay and coal are mined on the pillar-and-stall system, and the pillars are subsequently removed.

Treatment: From the level the clay is conveyed to the Henllys Works by rail, a distance of about 6 miles. At the works the clay is weathered 4 or 5 years; any ironstone-nodules not left underground at the level are picked out at the level-mouth or subsequently at the brickworks, where there is a large stock of clay in the tips.

The grog used consists of ground firebricks. In the case of some special goods requiring a higher silica percentage, crushed sandstone from the Millstone Grit of the Abersychan district has been employed; a sample shows the rock to be a soft friable white sandstone containing occasional small quartz-pebbles.

BEAUFORT SANITARY PIPE & BRICK CO., LTD.

Beaufort, Monmouthshire.¹

Works: Beaufort Brickworks, adjacent to north side of the L. & N. W. Railway, about $\frac{1}{4}$ mile west of Beaufort Station.

Quarry: Openworks 400 to 500 yards N.E. of the brickworks.

Maps: One-inch New Ser. Ordnance and Geological 232; six-inch Monmouth 11 N.W.

Latitude $51^{\circ} 48' 3''$. Longitude $3^{\circ} 12' 20''$.

Geological formation: Coal Measures; Lower Coal Series. Fireclay 8 ft. above the Old Coal.

The following details of the measures exposed in the openwork were supplied by the manager:—

								Ft.	In.
Yard Coal	...	...	...	...	...	...	...	1	10
Shale and clay	...	...	...	...	...	...	...	24	0
Little Coal	...	...	...	...	...	...	...	1	0
Buff clay	...	...	...	...	...	...	...	0	9
FIRECLAY (working), 6 ft. to	...	...	...	...	...	...	...	10	0
Rock	...	...	...	...	...	...	...	8	0
Old Coal, 4 ft. to	...	...	...	...	...	...	...	6	0
Ganister (so-called)	...	...	...	...	...	...	...	2	0
Clay	...	...	...	...	...	...	...	—	—

The shale beneath the Yard Coal is used for the manufacture of common red building-bricks, which form the main product of the works. The clay associated with this shale is used for making sanitary pipes. The 'ganister' under the Old Coal appears to be a siliceous fireclay. The beds are worked on their outcrop.

Reserves: The beds dip to the south-east, in which direction there are large reserves.

Mode of working: As an open quarry. No blasting is required. Ironstones are picked out.

EBBW VALE STEEL, IRON & COAL CO., LTD.

Ebbw Vale, Monmouthshire.

Works: Brynhelig Brick Works, Ebbw Vale.

Mine: Fireclay is obtained from the Company's Clay Level, Ebbw Vale, 300 or 400 yards N.E. of the Company's Iron Works.

Maps: One-inch New Ser. Ordnance and Geological 232; six-inch Monmouthshire 11 S.W.

Latitude (approximate) $51^{\circ} 46' 49''$. Longitude (approximate) $3^{\circ} 11' 58''$.

Geological formation: Coal Measures; Lower Coal Series. Fireclays above the Elled Coal.

¹ The address of the firm is given as "Beaufort, Breconshire," and this agrees with the Post Office Guide; but the county boundary seems to have been shifted farther northward some years ago, so that Beaufort has been included in Monmouthshire.

The clays worked are shown in the following section :—

	Ft.	In.
FIRECLAY (called No. 2), working	2	6
Black shales, working	3	0
Shales	1	6
Coal	0	8
FIRECLAY (called No. 1), working	2	0
Rock	0	8
Rashings	0	4
FIRECLAY (called the Elled Clay), working	5	0
Shales with thin sandstone at base	21	0
Elled Coal... ..	—	

Reserves : The beds dip S. 5° E. at about 15° , in which direction there are large reserves.

Mode of working : The clays are worked from a level on the pillar-and-stall system.

Treatment : The ironstone-nodules are picked out, though few are present. The grog used consists of ground firebricks. Tuyeres are made from No. 1 clay. Cement for setting firebricks is prepared by grinding the shales under the No. 2 clay.

DAVID MORRIS.

25, Badminton Grove. Ebbw Vale. Mon.

Mine : Ganister Level, at Sirhowy, about 350 yards S.E. of Trefil Station (L. & N. W. Railway), $1\frac{1}{2}$ miles N.W. of Ebbw Vale.

Maps : One-inch New Ser. Ordnance and Geological 232; six-inch Monmouthshire 11 N.W.

Latitude $51^{\circ} 47' 37''$. Longitude $3^{\circ} 14' 0''$.

Geological formation : Coal Measures; Lower Coal Series. Floor of the Old Coal.

The section is as follows :—

	Ft.	In.
Old Coal	{ Top coal	1 8
	{ Clod	1 6
	{ Bottom coal, about	3 6
'Ganister'	{ Dark fireclay with <i>Stigmara</i> (Top Bed)	0 9
	{ 'Ganister,' hard, grey (Middle Bed)...	2 3
	{ 'Ganister,' hard, dark-grey (Bottom Bed)	1 0

The so-called ganister is a hard siliceous fireclay.

Reserves : The beds, which have been worked by level at the outcrop, dip southward at 1 in $2\frac{1}{2}$. The level is now abandoned, but a new one is projected in an adjacent plot to the east.

Glamorgan.

GUEST, KEEN & NETTLEFOLDS, LTD.

Dowlais.

Brickworks at Dowlais Steel Works, Glamorgan.

Fireclay obtained from the Company's Viaduct Level at Pontnewynydd, near Pontypool (*see* report on the Company's Cwmbran Works, p. 195).

The fireclay is brought from Pontnewynydd to Dowlais by rail.

No grog is used for the ordinary firebricks, but for making tuyeres 20 per cent. of ground silica (obtained from No. 2 Bryniau Quarry) is added.¹

The whole output is used by the Company at Dowlais, except that occasionally some of the goods are sent to their Cardiff works.

CWMGORS BRICKWORKS CO., LTD.

Cwmgors, Gwaun-cae-gurwen, Glamorgan.

Works: Brickworks at Cwmgors, Gwaun-cae-gurwen, $1\frac{1}{2}$ miles S.W. of Brynamman.

Quarry: Open quarry adjacent to works.

Maps: One-inch New Ser. Ordnance and Geological 230; six-inch Glamorgan 2 S.E.

Latitude $51^{\circ} 46' 56''$. Longitude $3^{\circ} 52' 35''$.

Geological formation: Coal Measures; Lower Coal Series. Fireclay 30 ft. below Red Vein.

The quarry shows the following series of beds:—

	Ft.	In.
Boulder-clay	—	—
Red Vein Coal	4	6
Shales, about	30	0
Coal-streak	—	—
FIRECLAY (working)	4	6
Sandstone, grey, siliceous	0	6

The beds dip W.S.W. at 8° and crop out to the north-east.

Reserves: There are unlimited reserves to the dip and along the strike. The shales are used for the production of common red building-bricks, which form the bulk of the firm's output.

Treatment: The fireclay is reserved for firebrick goods. Any ironstone-nodules it may contain are picked out by hand. The clay is not weathered. Ground firebricks are used as grog.

Note:—The firm have experimented in the production of a siliceous firebrick from a mixture of their own fireclay with ground quartzite from the Millstone Grit of Brynamman, but shortage of labour has hindered further trials.

WERNDU COAL & BRICK CO., LTD.

Caerphilly, near Cardiff.

Works: Brickworks situated adjacent to the Rhymney Railway, $\frac{3}{4}$ mile S.E. of Caerphilly.

Quarry: Clay-pits in Gwern-ddu, 600 yards south of the Brickworks.

Maps: One-inch New Ser. Ordnance and Geological 249; six-inch Glamorgan 37 N.W.

Latitude $51^{\circ} 33' 49''$. Longitude $3^{\circ} 11' 55''$.

Geological formation: Coal Measures; Lower Coal Series. Red Vein and Big Vein Fireclays.

¹ For an account of the refractory materials from the Bryniau Quarries, see "Mineral Resources of Great Britain," vol. vi, Ganister and Silica Rock, etc. (Mem. Geol. Surv.), 2nd edit., 1920, p. 137.

The section of the beds exposed in the openworks is as follows:—

	Ft.	In.
Sandstone and shale, about	40	0
Red Vein Coal	4	6
FIRECLAY (occasionally worked)	9	0
Shale	6	6
Big Vein Coal	4	0
FIRECLAY (working)	50	0
Shale, about	4	0
Black Vein Coal		

The fireclay under the Red Vein is impersistent; but where it is present in sufficient quantity to be raised, it is laid aside and added to that from below the Big Vein for making firebricks. The coals are raised and sold, while the shales are used for common red building-bricks, which form the main output of the brick-works.

Reserves: The beds crop out to the south, and dip N. 15° W. at about 40°. In this direction reserves are unlimited. The output of fireclay is sufficient for an extension of the firebrick branch of the business.

Treatment: The ironstone-nodules present in the fireclay are removed. No weathering is regarded as necessary, because the clay is quarried on the outcrop. No grog is used.

THE TAWE CLAY WORKS CO.

Morryston.

Works: Situated on ground adjoining the clay-hole.

Quarry: On the mountain side at Ynysci near Ystalyfera, about 11 miles north-east of Swansea.

Maps: One-inch New Ser. Ordnance and Geological 230; six-inch Glamorgan 3 S.W.

Latitude 51° 45' 40". Longitude 3° 46' 20".

Geological formation: Coal Measures; Lower Coal Series.

The beds worked lie about 200 ft. below the Red Vein. About 40 ft. of black shales all suitable, after treatment, for ladle-linings are exposed in the quarry: there are numerous joints which split the shales into narrow pencil-shaped pieces. A thin bed of sandstone lies near the top of the quarry. Nodules of ironstone are present in the shale and the joints are stained with red oxide of iron.

The strata form part of a gentle anticline that pitches south-east and is faulted near the south-west end of the quarry, but the throw is only a few feet.

Reserves: There is a large area of clay at present untouched, both down the dip and along the strike.

Treatment: The clay is spread in low heaps on the floor of the quarry and left there to weather as long as possible.

No bricks are made. The output consists of ground clay supplied to steel-works for ladles.

MOODY BROTHERS & CO., LTD.

Clydach-on-Tawe, Glamorgan.

*Clydach Brickworks.**Works:* Situated at Clydach.*Pit:* Moody's Graigola Colliery: No. 1 (Level) No. 2 (Slant).*Maps:* One-inch New Ser. Ordnance and Geological 230; six-inch Glamorgan 8 S.W.Latitude $51^{\circ} 42' 35''$. Longitude $3^{\circ} 54' 20''$.*Geological formation:* Coal Measures; Pennant Series. Graigola Fireclay.

The pit is worked for coal; the fireclay, which is abundant, is got as required for use. The beds dip N.W. at 1 in 10.

Treatment: The fireclay was formerly weathered on tips, but now (1916) is used as it comes from the mine. It is ground under edge-runners in a perforated pan, which screens the clay sold for use at silica-brick works from that (the finer) employed in the manufacture of firebricks. Old bricks are ground to $\frac{1}{8}$ in. for grog.

DAVID REES & SONS AND JNO. J. RICHARDS & CO.

Lower Cwmtwrch.

*Gurnos and Darren Brickworks.**Situation:* Gurnos quarry and works adjacent to one another at Lower Cwmtwrch, 12 miles N.E. of Swansea.*Maps:* One-inch New Ser. Ordnance and Geological 230; six-inch Glamorgan 3 S.W.Latitude $51^{\circ} 46' 25''$. Longitude $3^{\circ} 47' 10''$.*Geological formation:* Coal Measures; Lower Coal Series. Clay under a leader of the Four-Foot, Little, or Pencraig Coal.

The quarry showed the following section in October, 1916:—

	Ft.
Thin seam of coal (a leader of the Four-Foot Coal), up to	3
FIRECLAY	9
Blue shale, for steel and spelter works	15-16
Rock	7
Shale	30
Coal (not working)	1 $\frac{3}{4}$

The beds dip south-west at 5° . Water offers no difficulties and there is no waste material. All the beds except the bottom coal are worked.*Reserves:* Abundant.*Treatment:* Weathering of all the clay is carried on as long as possible. No grog is added to the clay.

LLWYNDU BRICK CO.

Glais, Clydach-on-Tawe.

Works: Brickworks two-thirds of a mile N.E. of Glais (4 miles N.E. of Swansea).

Mine: Llwyndu Colliery; level and slant.

Maps: One-inch New Ser. Ordnance and Geological 247; six-inch Glamorgan 15 N.E.

Latitude $51^{\circ} 41' 47''$. Longitude $3^{\circ} 52' 0''$.

Geological formation: Coal Measures; Pennant Series. Graig-ola Fireclay.

The section of the Graigola coal and fireclay is as follows:—

	Ft.
Graigola Vein	5
Fireclay (working), average	3

The clay is black when unweathered, but becomes brown after exposure. The beds dip S.E. at 1 in 5.

Reserves: There are plenty of underground reserves and a large store on the tips. Workings are above adit-level, therefore water occasions no trouble. There is little waste from roof or from partings.

Mode of working: The clay is worked on the pillar-and-stall system. The old coal pillars are being worked, and with them the fireclay, which was left by the old miners.

Treatment: The clay is weathered for about six months. This breaks it down and exposes the 'pulses' or nodules of clay iron-stone. All the clay is used, no selection being made. No grog is added.

GRAIG BRICK CO.

Glantawe Street, Morriston.

Situation: The Graig Brickworks and open pit, situated at Graig Trewyddfa, Morriston, near Swausea.

Maps: One-inch New Ser. Ordnance and Geological 247; six-inch Glamorgan 15 S.W.

Latitude $51^{\circ} 39' 30''$. Longitude $3^{\circ} 55' 45''$.

Geological formation: Coal Measures; Pennant Series.

The section at Graig Trewyddfa is as follows:—

	Ft.
Five-Foot Vein (coal)	—
Brown clay (not working), over	30
Beds of stone, average	5
Soft blue clay (for terra-cotta facings)	4-5
Hard blue clay (for brindled bricks for acid-works, etc.)	7

The beds are nearly flat.

Reserves: There are large reserves along the strike in both directions. There are no water troubles or faults.

Mode of working: The quarry is worked in lifts. Stone partings are made up into 'tarmac.'

Treatment: No grog is added to the clay.

The principal goods made are brindled bricks for acid-works, with 'tarmac' and terra-cotta ware. No true firebricks are made.

Maps: One-inch New Ser. Ordnance and Geological 246; six-inch Carmarthenshire 58 N.W.

Latitude $51^{\circ} 41' 5''$. Longitude $4^{\circ} 11' 25''$.

Geological formation: Coal Measures; Pennant Series. Two fireclays under the Black Rock Coal.

The upper fireclay occurs under the Black Rock Coal; it is $2\frac{3}{4}$ ft. thick and the coal $1\frac{1}{2}$ ft. Another seam 20 yards along the level, or about $5\frac{1}{2}$ yards below the first, is 5 ft. thick and is a blacker and harder fireclay. The beds dip about east of south at 1 in 3.

Reserves: There are ample reserves in the mine.

Mode of working: A sort of pillar-and-stall system is used for getting the coal and clay. Water gives no trouble, but there is a quantity of waste from partings.

Treatment: The clay is not weathered. Broken bricks are used as grog.

LLOYD BROTHERS.

Pantyffynnon, Carmarthenshire.

Pontyclerc Collieries and Brick Works.

Works: Brickworks at Pontyclerc, $\frac{1}{2}$ mile N.N.W. of Pantyffynnon Station (G.W.R. and L. & N.W.R.), near Ammanford.

Mine: Pontyclerc slant adjacent to the works.

Maps: One-inch New Ser. Ordnance and Geological 230; six-inch Carmarthen 48 S.E.

Latitude $51^{\circ} 47' 3''$. Longitude $4^{\circ} 0' 4''$.

Geological formation: Coal Measures; Lower Coal Series. Fireclay 17 or 18 yards below the Rocket Vein.

The section is as follows:—

	Ft.	In.
Shales
Coal, 1 ft. to	1 2
FIRECLAY (working), darkest at top	2 6
Fireclay (with ironstone-nodules; not worked)	3 0

Reserves: The bed dips S. 10° E. at 12 in. per yard, and crops out to the north. In the direction of dip, about 140 acres remain to be worked, with the option of further extensions. There are large reserves on the tips.

Mode of working: The clay is worked by pillar-and-stall. Ironstone-nodules are picked out.

Treatment: The clay is weathered as long as possible; some parts of the present tips (1916) are three years old.

The firebricks of ordinary quality are made from the pure clay; but, for special goods, grog in the form of ground firebricks is added.

THOS. WILLIAMS & SONS (LLANGENNECH), LTD.

Llangennech, Carmarthenshire.

Llangennech Collieries.

Works: Brickworks situated at Talycllyn, $\frac{3}{4}$ mile S.W. of Pontardulais, 5 miles N.E. of Llanelly.

Mine: Fireclay obtained from the Talycllyn Slant adjacent to the Brickworks.

Maps: One-inch New Ser. Ordnance and Geological 230; six-inch Carmarthen 55 S.W.

Latitude $51^{\circ} 42' 42''$. Longitude $4^{\circ} 3' 44''$.

Geological formation: Coal Measures; Pennant Series. Golden Vein Fireclay.

The section is as follows:—

									Ft. In.
Shales	...	...	...	...	...	...	...	...	—
Coal (Golden Vein, working)	...	...	...	...	...	...	...	...	2 4
FIRECLAY (working)	...	...	...	...	...	...	...	...	1 8

The topmost part of the fireclay for about an inch in thickness is slightly darker than the rest.

Reserves: The beds crop out to the north; the slant follows the coal and clay down the dip, which is about southward at 9 in. in the yard. In this direction and westward there are large reserves. No serious faults have been encountered.

Mode of working: The minerals are worked on the pillar-and-stall system.

Treatment: Ironstone-nodules are picked out of the clay, which is weathered as long as possible, but at the present time three months is the limit. The kilns are fired with bituminous coal brought from another district, as the coal raised at Talycllyn is non-bituminous. No grog is used.

PWLL COAL AND BRICK CO.

Trefig, College Hill, Llanelly.

Situation: The Pwll Level is situated about $1\frac{1}{2}$ miles west of Llanelly. Works about 600 yards farther west, and connected by horse-tramway with the level.

Maps: One-inch New Ser. Ordnance and Geological 246; six-inch Carmarthenshire 58 N.W.

Latitude $51^{\circ} 41' 12''$. Longitude $4^{\circ} 11' 45''$.

Geological formation: Coal Measures: Pennant Series. Black Rock Coal and Fireclay.

The fireclay is 5 ft. thick. The dip of the beds is southerly at 1 in 4.

Reserves: There are plenty of reserves.

Mode of working: The mine is worked on the pillar-and-stall system. Water is easily disposed of.

Treatment: The clay is weathered as long as possible. Old bricks are ground and added as grog.

T. J. DAVIES & Co.

Llanelly.

Stanley Firebrick Works.

Situation: Works at Llanelly. Clays obtained (1) from the Leicestershire Coalfield through firms in Burton-on-Trent, and

(2) from the Pembrey Collieries Ltd., Burry Port, 4 miles west of Llanelly.

Maps: Pembrey Collieries: One-inch New Ser. Ordnance and Geological 246; six-inch Carmarthenshire 57 N.E.

Geological formation: Coal Measures: Pennant Series. Fire-clay under the Gyswrm Rider Coal.

The Gyswrm Rider lies 54 to 60 ft. above the Gyswrm Coal, which here is taken as the base of the Pennant Series. The Gyswrm Rider coal and fireclay are got by a level.

Reserves: There are plenty of reserves of the clay underground. The beds crop out towards the north-north-east and dip south-south-west.

Treatment: The clay is weathered at the mine and blended with other clays for stoppers, nozzles, sleeves, lining-bricks, etc. The grog added consists of ground burnt clay.

CHAPTER XVI.

SCOTLAND.

INTRODUCTION.

The Scottish fireclays worked at the present time for high-class refractory material are almost entirely confined to the Millstone Grit of the Central Valley.

A few seams are wrought near the base of the Coal Measures in the Falkirk district.

In the Calciferous Sandstone Series of the Paisley district in Renfrewshire several fireclays have been worked, the most important being the Ferguslie Seam. No clay is raised here at present, but the field is far from exhausted and further development is certain.

The "coal seats" below several of the coals in Lanarkshire, Stirlingshire, Linlithgowshire, East Lothian, Ayr and Fife are also made use of in the production of fireclay goods of secondary value.

The fireclay fields of Lanarkshire and East Stirlingshire are well known, and have long been the seat of an important industry. There are large reserves, and considerable areas exist in which the clay is as yet almost untouched. The Millstone Grit fireclays on the east side of the Lanarkshire coalfield have been proved in bores, and are now being tentatively worked in Linlithgowshire, but have still to be exploited over a large area.

The Millstone Grit fireclays of North Ayrshire have recently been the subject of investigation by the Geological Survey and by private firms: they have proved to be a source of valuable refractory material and are now (1918) being worked to a considerable and increasing extent. References to the different localities from which samples have been tested and analysed will be found in the following pages.

The position of the more important fireclays in the Millstone Grit and Coal Measures of the Central Coalfield is indicated in the tables below.

Millstone Grit: Glenboig, Castlecary and Bonnybridge Districts.

Depth. Fms.	Slatyband Ironstone—base of Coal Measures.	Thickness,		
		Fms.	Ft.	Ins.
	Strata	26	3	0
29	*Upper Fireclay, Bonnybridge (Fireclay, coal, ganister)...	3	0	0
	Strata	30	0	0
61	Fireclay	2	3	0
	Strata	15	0	0
80	'Silica Rock' and fireclay	4	0	0
	Strata	4	3	0
85	Fireclay	1	0	0
	Strata	13	0	0
100	*Fireclay	1	4	0
	Strata, mainly sandstone	10	0	0

Depth Fms.			Thickness.		
			Fms.	Ft.	Ins.
111	Lower Fireclay	*Fireclay—'Blue Seam' of Glenboig	...	1	0 8
		Silica Rock of Glenboig	...	1	1 0
113	Strata	*Main Seam of Glenboig and Castlecary	...	7-10	
		...	...	2	0 0
	Curdly Ironstone	...	...
115		Cement Limestone	...	1-2	0 3
	'Cement Fireclay' of Glenboig	...	...	4	0 0
		Strata	...	4-5	0 0
	*Fireclay—'White Seam' of Castlecary	...	...	6	0 0
123		Castlecary Limestone	...	1-5	0 0

* Fireclays worked at the present time.

The thicknesses given in the above table are liable to great variation. The upper half of the section is derived from borings and mine workings near Bonnybridge Station on the North British Glasgow to Edinburgh Railway; the lower half from similar data in the Castlecary and Glenboig districts. (See Plate IV.)

Lower Part of Coal Measures: east and south-east of the Central Coalfield.

<i>Herdhill District.</i>	<i>Morningside District.</i>	<i>Armadales District.</i>	<i>Falkirk Coalfield.</i>
Kiltongue Coal, 42 in.	Kiltongue Coal, 18-31 in.		
	*FIRECLAY.		
Strata, 5-6 fms.	Strata, 6-8 fms.		
Upper Drumgray Coal, 20 in.	Upper Drumgray Coal, 20 in.		
Strata, 6 fms.	Strata, 5-7 fms.		
Mid Drumgray Coal, 48 in.	Lower Drumgray Coal, 30 in.		
*FIRECLAY.	*FIRECLAY.		
Strata, 5 fms.	Strata, 5½-7½ fms.		
Lower Drumgray Coal, 21 in.	Smithy Coal, 21 in.		
Strata, 5 fms.	Strata, 5 fms.		
Gas Coal, 13 in.	Gas Coal, 13 in.		
Strata, 11-12 fms.	Strata, 10 fms.		
Mill Coal, 15 in.	Mill Coal, 19 in.	Mill Coal, 24 in. Strata, 9½ fms.	Mill Coal, 24 in. Strata, 7 fms.
		Ball Coal, 24 in.	Ball Coal, 24 in.
		*FIRECLAY.	*FIRECLAY.
		Strata, 4½ fms.	Strata, 5 fms.
		*FIRECLAY.	
		Main Coal, 40 in.	Main Coal, 30 in.
		*FIRECLAY.	
		Strata, 10½ fms.	Strata, 10 fms.
		Colinburn Coal, 30 in.	Highstone Coal, 12 in.
		*FIRECLAY.	
		Strata, 1½ fms.	Strata, 3½ fms.
		Armadales Slaty- band, 9 in.	Bonnyhill Craw Coal, 12 in.
		Strata, 6 fms.	*FIRECLAY. Strata, 5 fms.
		Slatyband position.	*FIRECLAY Slatyband Iron- stone.

* Fireclays worked at the present time.

Central Coalfield.

Millstone Grit Fireclays: The Lower Fireclay.

The Millstone Grit fireclays of Lanarkshire and Stirlingshire have long been known as a source of valuable material for refractory products: the manufacture of fireclay goods is at the present time an important and increasing industry and employs a large number of hands.

The fireclays now wrought in this region occur at two definite horizons in the Millstone Grit, distinguished under the names of the Lower and Upper Fireclays. The principal seam of the *Lower Fireclay* lies at a distance varying in different localities from 12 to 30 ft. above a thin bed of marine limestone, called locally the "Cement Limestone," or "Roman Cement." This band is, so far as is known, generally persistent on both the east and west sides of the Lanarkshire coalfield and also round the southern extremity of the basin, and affords a reliable index to the position of the Lower Fireclay. It is locally accompanied by a bed of nodular clayband ironstone—the Curdly Ironstone.

The 'Cement-stone' varies in character from a shelly limestone characterised by an abundant *Orthis* shell, to a hard, dark, ferruginous dolomite: it lies 40 to 60 ft. above the top of the Castlecary or Levenseat Limestone, which is regarded as the base of the Millstone Grit. The strata between the two limestones usually include a thick white sandstone, sometimes quarried for moulding sand.

Mining operations in the Lower Fireclay have, up to the present time, been almost entirely restricted to the west side of the Lanarkshire basin where it has been proved in many localities from north to south between Plean in Stirlingshire and Gartsherrie near Coatbridge.

Although the general horizon of these fireclays seems to be persistent over a large area, the thickness and quality of the individual seams are subject to constant variation. The average normal thickness of the principal seam is 6 to 9 ft., but through local erosion it is sometimes reduced to a few inches or pinched out altogether, the sandstone roof descending towards the pavement of the seam.

The constant variation in the quality of these clays renders the production of fireclay goods a very complex process, in which skilled selection and careful manipulation are required in order to obtain the best results. The best fireclays are, as a rule, whitish or pale lilac-grey in colour. That colour cannot, however, be taken as an invariable test of quality is shown by the fact that certain dark clays such as the "blue clay" of Glenboig have lately been found to possess high refractory qualities. Bedding-planes are usually indistinct, but are sometimes indicated by thin layers of sandstone or lines of ferruginous nodules known as "button beds."

The opencast workings of the Garnkirk district have long been abandoned, and the clay is now raised from pits, and mines from the crop, the overlying sandstone forming a good roof.

On the south-eastern margin of the Lanarkshire coalfield the Lower Fireclay position has been passed through repeatedly in bores, but no attempt has yet been made to prove the value of the clays met with. Locally they appear to be very thick, and are described as "fireclay, fireclay blaes and balls." The 'Cement-stone' is here represented by a thin limestone underlying the Curdly Ironstone of Breich and Levenseat.

In Linlithgowshire mining operations in a fireclay on the horizon of the Lower Fireclay of Lanarkshire have recently been started on the banks of the River Avon, near Bo'ness.

The different workings in the Lower Fireclay will now be described in detail.

THE GLENBOIG UNION FIRECLAY COMPANY, LTD.

Glenboig, Lanarkshire.

Glenboig Fireclay Works. Star and Klondyke Pits and Inchnock Mines.

Situation: The Star Pit in Glenboig; Klondyke Pit, $\frac{1}{2}$ mile N. of Glenboig Station; Inchnock Mines, $\frac{3}{4}$ mile W.N.W. of Glenboig Station.

Maps: One-inch Ordnance and Geological 31; six-inch Lanark 7 N.E., 2 S.E. The six-inch geological maps, revised edition, have also been published.

(Star.) Latitude $55^{\circ} 53' 54''$. Longitude $4^{\circ} 2' 3''$.

(Klondyke.) Latitude $55^{\circ} 54' 8''$. Longitude $4^{\circ} 2' 50''$.

(Inchnock.) Latitude $55^{\circ} 53' 50''$. Longitude $4^{\circ} 3' 7''$.

Geological formation: Millstone Grit, Lower Fireclay.

The position of the Lower Fireclay in the Glenboig district is from 50 to 60 ft. above the base of the Millstone Grit, and 12 to 14 ft. higher in the series than the Cement Limestone. Above the Main seam, which averages 6 to 9 ft. in thickness, and separated from it by a bed of sandstone never more than 12 ft. thick and sometimes thinning down to a mere rib, is a seam of dark clay 4 to 5 ft. thick, often with abundant rootlets, and coaly at the top. In the Gain Workings of the Glenboig Union, where it is known as the 'Blue Clay,' this is the better seam, and affords the most refractory material. Its position elsewhere than at Gain is occupied by a similar dark and very planty bed, called the 'Twiggy Clay.'

The Lower Fireclay is raised at Glenboig from mines along the crop northwards to Inchnock, and from the Star and Klondyke Pits, where the floor of the seam lies respectively 18 and 31 fms. from surface. In the Klondyke workings, which to the north approach a powerful east-and-west fault, the strata are often disturbed: at one point the seam is thrust upon itself for a distance of about 60 ft., thus considerably increasing the thickness of the bed.

The overlying strata are chiefly made up of sandstones and

faky fireclays, but also include the Inchnock dolerite sill, 18 to 30 ft. in thickness. At the Star Pit the base of the sill is 13 fms. above the Lower Fireclay, but the intrusion passes rapidly down through the metals to the north-east, and at Gain lies some distance below the fireclay.

Reserves: There are ample reserves of the Lower Fireclay still in sight and a new field is being opened up by the Glenboig Union, in ground 2 to 3 miles N.E. of Glenboig, where the seam, 7 ft. in thickness, is now being worked in a mine between Bellstane and Mossywood.

Further to the north the evidence afforded by natural sections and recent bores warrants the belief that a large field of the Lower Fireclay is present at no great depth below the surface, between the head of the Luggie Water and the Walton Burn above Kilt, and may extend northwards to the dolerite dyke south of Castle-cary Low Wood.

Gain Mine.

Situation: One mile N.N.E. of Glenboig Station.

Maps: One-inch Ordnance and Geological 31; six-inch Lanark 2 S.E.

Latitude $55^{\circ} 54' 40''$. Longitude $4^{\circ} 2' 0''$.

As already noted the dark clay above the main Glenboig seam is worked here and affords material of high refractory value.

A ganister brick is made from the siliceous sandstone which separates the 'Blue Clay' from the lower seam; it is used for the crowns of steel furnaces and coke ovens.

Gartcosh Pit.

Situation: Gartcosh, about 2 miles W.S.W. of Glenboig.

The Lower Fireclay at Gartcosh is found at an average distance of 12 ft. above the Cement Limestone: the seam measures 8 ft. in thickness.

The Gartcosh clay is not quite so refractory as that of Glenboig though from the same seam. It is therefore not adapted for the most highly resistant goods, but is used, without any admixture, for ordinary firebricks and tiles. A white, siliceous sandstone lying immediately above the fireclay is used, to a small extent, for the manufacture of silica bricks with a lime bond. The clay is burnt in gas kilns at the works, near Gartcosh Station.

Glencryan Mine.

Situation: 1 mile E. by N. of Cumbernauld Station on the Caledonian Railway: 5 miles N.E. of Glenboig.

Maps: One-inch Ordnance and Geological 31; six-inch Stirling 34 N.E.

The geological six-inch sheet is also published in the revised edition.

Latitude $55^{\circ} 56' 35''$. Longitude $3^{\circ} 57' 22''$.

The Lower Fireclay is worked here by a mine driven north-eastwards from the crop to the dip of the seam, at 5° .

The section of the mine is as follows:—

	Ft.	In.
Hard yellowish sandstone (roof of mine)	—	—
LOWER FIRECLAY	4	9
Sandstone	9	0
Fireclay, inferior	4-6	0
Cement Limestone in two bands with blaes parting ...	1	6
Dark blaes and coal, 2 in.	0	4
Faky fireclay	3	0
Sandstone	35	0
Dark blaes with ironstone nodules	5	6
Rough ferruginous limestone (Castlecary)	0	7
Blaes.		

At the air shaft No. 2, 580 yards from the mouth of the mine, the Lower Fireclay is 50 ft. from surface.

The Glencryan clay is used for bricks and blocks for lining steel and iron furnaces; also for ordinary fireclay goods.

PETER AND MARK HURLL, LTD.

144, West Regent Street, Glasgow.

Garnqueen and Gartliston Pits.

Situation: Glenboig, $\frac{1}{2}$ mile S.S.W. of Station.

Maps: One-inch Ordnance and Geological 31; six-inch Lanark 7 N.E.

(Garnqueen) Latitude $55^{\circ} 53' 8''$. Longitude $4^{\circ} 2' 40''$.

(Gartliston) Latitude $55^{\circ} 53' 4''$. Longitude $4^{\circ} 2' 37''$.

Geological formation: Millstone Grit, Lower Fireclay.

The Lower Fireclay is found in the Garnqueen Pit at a depth of 17 fms.

The section of the seam is as follows:—

	Ft.	In.
Sandstone	29-30	0
FIRECLAY	10-12	0
'Hard Stone'	4	0
FIRECLAY, inferior to Upper Seam	4	0
Black 'whin'	0	10
Coal	0	4
Sandstone	4	0

The beds dip S.S.W. at 1 in 5.

At the Gartliston workings, where the Lower Fireclay is $39\frac{1}{2}$ fms. from surface, the metals are dipping S.S.E. at 10° : the Cement Limestone here lies 20 ft. below the pavement of the fire-clay seam.

At the present time no clay is being raised at Garnqueen, the works having been temporarily leased to the Eglinton Silica Brick Co., for the manufacture of magnesite bricks from imported material.

THE HEATHFIELD AND CARDOWAN FIRECLAY CO., LTD.

52, Robertson Street, Glasgow.

Heathfield Fireclay Works.

Situation: The Heathfield Pit is situated at the side of the

Caledonian Railway, $\frac{1}{2}$ mile to the east of Garnkirk Station: the works are close to the same station.

Maps: One-inch Ordnance and Geological 31; six-inch Lanark 7 N.E.

The revised six-inch geological map is also published.

Latitude $55^{\circ} 53' 23''$. Longitude $4^{\circ} 6' 10''$.

Geological formation: Millstone Grit; Lower Fireclay.

The principal seam of fireclay wrought at Heathfield lies 40 fms. from surface at the shaft and 24 ft. above a limy ironstone which here occupies the position of the Cement Limestone: the Heathfield clay is no doubt on the same horizon as the Lower Fireclay of Glenboig. The thickness of the seam varies from 10 ft. to 25 ft. as an extreme maximum.

A bed of siliceous white sandstone, about 22 fms. above the fireclay, is ground and mixed in varying proportions with the clay for the manufacture of siliceous bricks.

CASTLECARY FIRECLAY CO., LTD.

Castlecary, Stirlingshire.

Maps: One-inch Ordnance and Geological 31; six-inch Stirling-Dumbarton 29 N.E.

Latitude $55^{\circ} 58' 54''$. Longitude $3^{\circ} 56' 48''$.

Geological formation: Millstone Grit; Lower Fireclay.

Working fireclay, ganister and occasionally limestone.

The base of the Lower Fireclay, here known as the Main seam, lies 25-30 ft. above the Cement Limestone, and about 10 fms. above the Castlecary Limestone. The Main seam averages 8-9 ft. in thickness, but the upper surface of the clay is often eroded, causing constant variation in the thickness of the seam.

The section, where now being wrought, is as follows:—

								Ft. In.
Sandstone	...	...	...	...	...	...	...	—
Bastard fireclay	...	...	...	...	...	...	...	2 6
MAIN FIRECLAY	...	...	...	...	...	...	...	7 0
Rock floor	...	...	...	...	...	...	...	—

The bastard fireclay is sometimes absent and the good clay increases to upwards of 8 ft. in thickness.

A lower seam of fireclay, lying 3 ft. above the top of the Castlecary Limestone, was worked to a small extent before the war, 200 or 300 tons being exported every month to Germany (use unknown). Samples from this seam were recently submitted to Shaw's Glazed Brick Co., Darwen, and as a result of their tests it appears to be a highly refractory clay.

Immediately beneath this fireclay, and separated from the limestone by 12-18 in. of dark blaes, is a 2 ft. bed of white "ganister." This is a fine-grained grey sandstone containing a certain amount of mica and argillaceous material in the matrix; the silica percentage is 90-92; the quartz grains are angular to subangular, and measure 0.075 mm.

The fireclays and ganister are worked from a pit immediately north of the railway at Castlecary Station: the ganister workings follow the old workings in the limestone. A mine recently

driven from the latter to catch the Main Fireclay seam, passed through an 8-ft. bed of clay, situated apparently midway between the Main and Lower seams. This clay has been analysed and promises to yield good refractory material.

Reserves: Ample reserves in view.

J. G. STEIN AND CO., LTD.

Castlecary Pits.

Situation: Two-thirds of a mile east of Castlecary Station.

Maps: One-inch Ordnance and Geological 31; six-inch Stirlingshire 29 N.E.

Geological formation: Millstone Grit, Lower Fireclay.

The base of the Millstone Grit is here 68 fms., the Cement Limestone 61 fms. from surface. The beds dip eastwards at low angles: a short distance to the south the Millstone Grit strata are cut off by an east-and-west fault with a downthrow to north of 50 to 60 fms.

In the Millstone Grit area around Plean and Torwood, north of Larbert, Stirlingshire, fireclays in the same geological position as the Lower Fireclay of Lanarkshire are exposed in a natural section in Torwood Glen and have been met with in bores recently put down at Carbrook Mains (No. 3) and Rosehill, at a depth respectively of 40 and 100 fms.

Little is at present known as to the nature and quality of these fireclays: it is possible that a field of workable clay may be found in this district.

Linlithgowshire.

Maps: One-inch Ordnance and Geological 31; six-inch Linlithgowshire 1 S.W.

A thick fireclay of good quality is exposed along the gorge of the River Avon at the point where that stream is crossed by the viaduct carrying the Bo'ness and Manuel railway, and also in the cutting immediately to the north. This fireclay lies a short distance above the base of the Millstone Grit, and is believed to be on the same stratigraphical horizon as the Lower Fireclay of Lanarkshire.

The clay has been wrought in former years, and is now again being worked on a small scale by Messrs. Hurl in the ground between the railway cutting and the river.

The thick fireclay at 11 fms. 4 ft. in Fig. 12 was mined by a day-level on the north side of the river just east of the viaduct. It is believed to be of good quality, and must be in much the same geological position as the Lower Fireclay of Glenboig.

The section exposed in the railway cutting includes beds that are also seen on the south-west side of the Avon close to Tod's Mill. The 7-fm. fireclay of the cutting varies rather rapidly in

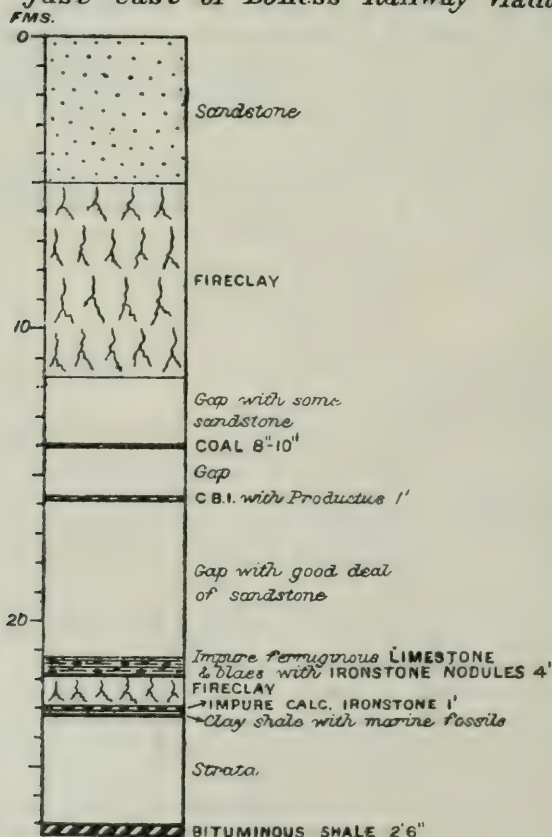
character. In one place it showed the following sub-divisions:—

	Fms.	Ft.
Dark grey fireclay...	1	2
Pale and dark grey fireclay	2	3
Purple and red fireclay	0	4
Fireclay with ironstone nodules...	0	5
Pale fireclay	0	5
Fireclay and ganister	0	5

Fireclay belonging to this 7-fm. bed was formerly worked near the crop just south-west of the railway-cutting. More recently Messrs. P. and M. Hurll have tested various samples of the fireclay in the cutting, and are preparing to work the clay again. Mr. M. Hurll states that the dark grey clay at the top gives the palest and best bricks. He believes that the 7-fm. fireclay in the cutting is the same as the thick clay of Fig. 12. This it may be, for an east-and-west fault that crosses the Avon near Tod's Mill has certainly a downthrow to the south, though it is difficult to fix

FIG. 12.

*GENERAL SECTION in the AVON VALLEY
just east of Boness Railway Viaduct.*



its exact amount. On the other hand, there is no very close resemblance between the beds below the fire-clay in the railway-cutting and those which, on the supposition referred to, should correspond with them. It is possible, therefore, to regard the strata in the railway-cutting as above any of the beds of Fig. 12, but in that case the fault between the two sections must be quite small.

The 7-fm. fireclay of the cutting can be traced north-west until it comes down to the river side at a point about 1,400 ft. north of Tod's Mill.¹

Millstone Grit Fireclays: The Upper Fireclay.

Certain fireclay and ganister seams that occur near the top of the Millstone Grit Series have been collectively designated the *Upper Fireclay* to distinguish them from similar beds—the *Lower Fireclay*—near the base of the series. To the *Upper Fireclay* belong the seams worked in the Bonnybridge district; at Torbanehill, Whitburn, and Hareshaw, Shotts. From the fact that they are well-developed and have long been wrought in the first of these districts, they are also known as the *Bonnybridge Fireclays*.

It cannot be asserted that all the fireclays in the different districts described below lie exactly on the same horizon: such exact correlation, over a widely spread area, is, for the following reasons, impossible.

(1) The upper limit of the Millstone Grit is, in the Central Coalfield, drawn at the Crofthead Slatyband Ironstone, a useful and convenient horizon over large areas, but in many cases difficult of recognition and capable of only an approximate determination of position.

(2) The great variation in the thickness of the Millstone Grit:—At Bonnybridge 113 fms., at Torbanehill about 76 fms., at Hareshaw about 55 fms.

(3) Lateral variation and local erosion of the seams: this, as already mentioned in reference to the *Lower Fireclay*, is very characteristic of the strata of the Millstone Grit.

It is therefore not always possible to correlate a particular seam in different localities or to assume that the *Upper Fireclays* are as a whole well-developed in any particular area. A careful consideration of the facts, however, warrants the statement that the fireclays wrought at Bonnybridge, Torbanehill, Hareshaw, and the other localities mentioned below, occupy approximately the same relative position in the Millstone Grit sequence and may therefore be grouped together for purposes of description.

The *Upper Fireclay* includes both refractory clays and ganisters or ganister-like sandstones. In some cases there are two or three seams, both of fireclay and ganister; in others a ganister lies between two thick clays, while there is generally associated with

¹ 'The Economic Geology of The Central Coalfield, Scotland' Area ii. (*Mem. Geol. Surv.*), 1917, p. 42.

them a somewhat impure coal, from a few inches up to 2 ft. in thickness.

The group is generally overlain by a massive and very pure white sandstone.

The fireclays are usually dark in colour: some of the best are, however, light grey, with a tinge of lilac or reddish-brown. They are, as a rule, full of rootlets, and locally contain nodules of iron-stone and lenticular masses of hard ganister-like sandstone.

Bonnybridge has for many years been an active centre for the manufacture of refractory goods of all kinds. At the present time (1916) the fireclay and ganister are being worked by six different firms, all of whom, in addition to selling the material in the raw state, have brickworks of their own. These are all situated close to the North British main line between Glasgow and Edinburgh, and within a short distance of Greenhill Junction on the Caledonian main line to Stirling.

Sections of the different workings and notes on the material raised are given later under the names of the individual companies.

Treatment and uses: The raw clay is weathered in the open for some time; it is then ground in dry and wet pans. The bricks are largely hand-moulded, but machines are employed to some extent. The bricks are dried on hot floors and burnt in kilns; both the round down-draught and continuous type being in use.

"Grog," of already burnt material, such as old firebrick, may be used, the amount varying with the nature of the clay and of the article to be made.

The ground clay is sold, both in the wet and dry condition, to foundries, steel- and chemical-works. The range of fireclay goods manufactured is wide. A special local industry is the manufacture of backs and sides for stoves and grates of all kinds.

Other articles manufactured include:—Bricks and blocks for—Bessemer ladle linings; cupola linings; gas producers; chequer-work in regenerative chambers; doors of Siemens-Martin furnaces; retort doors; blast and puddling furnaces; coke-ovens and gas works; boiler seats and flue covers; brick-work of soaking pits; and nozzles, stoppers and sleeves.

Reserves: These are ample, even with respect only to the present leases of the firms now operating.

The firms now working fireclay and ganister in the Bonnybridge district are given below.

JAMES DOUGALL & SONS, LIMITED.

Bonnybridge.

The Bonnyside Fireclay Works.

Situation: Close to Bonnybridge Station on the N.B. Glasgow-Edinburgh line.

Maps: One-inch Ordnance and Geological 31; six-inch Stirling 30 N.W.

Latitude 55° 59' 26". Longitude 3° 52' 10".

Geological formation: Millstone Grit, Upper Fireclays.

Section of workings:—

						Ft.	In.
Sandstone roof.							
TOP FIRECLAY...	...	...	...	...	...	2	9
Coal ...	...	...	...	...	...	1	6
Brown stone rib	...	...	...	...	...	0	4
Coal ...	...	...	...	...	...	0	3
TOP GANISTER...	...	...	...	...	...	3	0
MID FIRECLAY	...	...	...	...	...	5	0
BOTTOM GANISTER	...	...	...	...	...	3	0
BOTTOM FIRECLAY	...	...	...	...	...	1	8
Rock Pavement	...	...	...	...	...	—

The seams of fireclay and ganister vary from point to point and the full working ranges from 13 to 22 ft. in thickness. The seams are worked on the stoop-and-room system: the top clay working is kept about 9 ft. in advance; the coal is then stripped off and the underlying ganister and fireclays wrought. The coal sometimes reaches 2 ft. in thickness; it is somewhat pyritous, but supplies fuel for the boilers. The Mid Fireclay is considered the best seam; it furnishes material for patent stoppers, nozzles, etc.

BONNYBRIDGE SILICA & FIRECLAY Co., LTD.

Bonnybridge.

Drum Mine.

Situation: Works and mine close to Bonnybridge Station, on the N.B. Glasgow-Edinburgh line.

Maps: One-inch Ordnance and Geological 31; six-inch Stirling 30 N.W.

Latitude 55° 59' 22". Longitude 3° 52' 27".

Geological formation: Millstone Grit, Upper Fireclays.

Section of working:—

						Et.	In.
Sandstone roof.							
TOP FIRECLAY	...	...	...	...	...	5	0 (first working).
Coal ...	...	...	...	...	...	1	4
Brown rib	...	...	...	...	...	0	5
MID FIRECLAY	...	...	...	...	...	2	0
GANISTER	...	...	...	...	...	3	0
BOTTOM FIRECLAY	...	...	...	...	...	6-8	0

Locally the Top Fireclay is wanting and the sandstone rests directly on the coal. The different seams vary considerably in thickness. The lowest seam here furnishes the best quality of clay and no doubt corresponds in part to the Mid Fireclay of Bonnyside. The seams were formerly worked from a 12-fm. shaft, but are now raised by a mine. The method of working is practically the same as at Bonnyside.

DYKEHEAD GANISTER & FIREBRICK CO., LTD.

Bonnybridge.

Dykehead Mine.

Situation: The mine is situated at the side of the main North British Railway, Glasgow to Edinburgh Line, and is half a mile east from Greenhill Junction on the Caledonian Railway.

Maps: One-inch Ordnance and Geological 31; six-inch Stirling 30 N.W.

Latitude $55^{\circ} 59' 21''$. Longitude $3^{\circ} 52' 45''$.

Geological formation: Millstone Grit, Upper Fireclays.

This mine formerly produced only fireclay; but early in the war the proprietors decided to meet the increasing demand for silica bricks by working the associated ganister seams as well. The former company (Geo. Turnbull & Co.) was reconstituted under the above title and the mine has been greatly extended and deepened. For additional information see 'Special Reports on the Mineral Resources of Great Britain', vol. vi, Ed. 2, 1920, p. 142.

The seams wrought outcrop near the mine-mouth and are worked to the dip.

The fireclay was carted to the Bonnymuir works at Bonnybridge, a distance of about a mile. It was chiefly used in the manufacture of bricks and backs for stoves, ranges and grates.

GLENYARDS FIRECLAY COMPANY.

Greenhill, Bonnybridge.

Glenyards Mine.

Situation: Mine and works about 1 mile west of Bonnybridge Station, $\frac{1}{4}$ mile from Greenhill Station.

Maps: One-inch New Ser. Ordnance and Geological 31; six-inch Stirling 29 N.E.

Latitude $55^{\circ} 59' 9''$. Longitude $3^{\circ} 53' 40''$.

Geological formation: Millstone Grit, Upper Fireclays.

The fireclay and ganister were formerly raised here from a shallow shaft. Owing to trouble with subsidences and water the old workings were abandoned and a mine driven to catch the seam farther to the east. The section in the old workings was somewhat variable, but a fair average gave:—

	Ft. In.					
Sandstone roof.						
Sandstone and blaes						3 0
Foul coal, up to						1 2
FIRECLAY						5-7 0
GANISTER						2 0
FIRECLAY						6-8 0
Sandstone.						

The section is much the same as at Bonnybridge save that the Top clay there is here represented by sandstone and blaes.

The new mine struck fireclay at a depth of 7 fms. but it proved thin and very irregular.

CAMPBELL & Co.

Roughcastle, Falkirk, Stirlingshire.

Roughcastle Fireclay Mine.

Situation: About one mile east of Bonnybridge Station, on the North British Railway, Glasgow-Edinburgh line.

Maps: One-inch Ordnance and Geological 31; six-inch Stirling 30 N.W.

Latitude $55^{\circ} 59' 43''$. Longitude $3^{\circ} 51' 0''$.

Geological formation: Millstone Grit, Upper Fireclays. (See also p. 221.)

Three seams of fireclay or ganister are wrought here. The lowest of these lies in the Millstone Grit and occupies the same position as the Upper Fireclay wrought at Bonnybridge. The section shows:—

							Ft.	In.
Sandstone	...	...	...	...	...	...	60-80	0
FIRECLAY	...	...	...	...	...	...	3	0
Coal	...	...	...	...	...	...	1	8
Brown stone rib	...	...	...	...	...	...	0	5
FIRECLAY	...	...	...	...	...	...	5	0

The fireclay underlying the coal is locally represented by a ganister—a somewhat friable fine-grained micaceous sandstone, pale-grey in colour, and streaked with carbonaceous matter.

Reserves : Large.

CALDER FIRECLAY CO.

Coatbridge.

Hareshaw Fireclay Mine, Shotts.

Situation: The mine lies close to the Drumbowie branch mineral railway, $1\frac{1}{2}$ miles east of Newhouse, and about $\frac{3}{4}$ mile west of south from Salsburgh. The raw material is railed to the works at Whifflet, Coatbridge.

Maps: One-inch Ordnance and Geological, Sheet 31; six-inch Lanark 12 N.E.

Latitude $55^{\circ} 50' 0''$. Longitude $3^{\circ} 53' 2''$.

Geological formation: Millstone Grit.

The section of the seam is:—

	Ft.	In.
Sandstone.	0	9
Wild Coal	6	0
FIRECLAY	2	0
Coaly fake	—	—
Faky fireclay	—	—

The horizon of this clay is shown in the following table:—

	Ft.	In.
Base of Coal Measures.		
Strata, about	71	0
Hareshaw Seam { Wild Coal	0	9
{ FIRECLAY	6	0
Mainly sandstone	57	0
Goodcockhill Ironstone	0	to 3 0

The seam contains balls of clayband ironstone which are picked out at the mine before loading.

Reserves : Probably large.

UNITED COLLIERIES LTD.

109, Hope Street, Glasgow.

Drum Pits.

Works : Atlas and Etna Brickworks at Armadale, about $\frac{1}{2}$ mile south-east of the village.

Mines : Drum Pits, Torbanehill, Whitburn, rather less than $1\frac{1}{2}$ miles south-east of Armadale Station.

Maps : One-inch Ordnance and Geological 31; six-inch Linlithgow 9 S.W.

Latitude $55^{\circ} 52' 29''$. Longitude $3^{\circ} 39' 56''$.

Geological formation : Millstone Grit, Upper Fireclays.

The upper portion of the Millstone Grit at this locality contains several seams of fireclay of workable thickness. The general sequence of beds is as follows :—

							Ft.	In.
Strata, largely sandstone	...	...	...	about	60	0		
TOP FIRECLAY of Drum Pits	...	...	...	up to	8	0		
Dark blaes	...	...	...	...	A few inches.			
Coal	...	...	...	...	0	8		
FIRECLAY	...	...	...	...	0	6-21		

Other seams of fireclay have been proved at a further depth of $3\frac{1}{2}$ fms.

The Drum Pit clays vary a good deal in thickness: the Top seam—the one so far chiefly wrought—averages about 3 ft. 6 in.; it is dark in colour with a slight tinge of purple, and contains numerous films of carbonaceous material (rootlets).

Reserves : Large.

Potential Resources of Millstone Grit Fireclay.

Of the fireclays wrought at present in the Millstone Grit on the west side of the Central Coalfield there are still very large reserves in the neighbourhood of existing mines or shafts. There are also large areas where the value of the Upper and Lower Fireclays has not yet been proved; fireclays also occur at other horizons throughout the same series which are still untried.

East side of the Lanarkshire basin.—Strata of Millstone Grit age occupy a continuous strip of country from Inveravon on the Forth to Whitburn and Handaxwood: this outcrop expands to the south to form the barren upland tract of the Gladsmuir Hills and Auchterhead Muir. Here, too, may be included the anticline of Millstone Grit running N.N.W. from Allanton and pitching below the Coal Measures at Salsburgh. The thickness of the Millstone Grit varies a good deal throughout. On the Forth it may possibly be as much as 130 fms.; at Whitburn it is approximately 77 fms.; at Levenseat 76 fms.; near Salsburgh 55 to 58 fms.

Throughout this area very little is known of the quality of the fireclays, but seams of workable thickness are frequently recorded in bores. The only workings at present raising Millstone Grit clays are Drum Pits, Torbanehill, and Hareshaw Mine near Salsburgh; at both of these the fireclay wrought lies near the top of the Series.

The Lower Fireclay is now being worked on the river Avon near Bo'ness by Messrs. Hurll; *see* p. 213.

The Millstone Grit fireclays of the area are dark or pale-grey in colour, or sometimes present a rusty-brown appearance. They are generally very soft and incoherent when exposed to the weather, but sometimes contain beds of hard "seedy" (sphaeroiderite) fireclay. Thick fireclays occur very constantly at the following horizons.

(1) Associated with the Bowhousebog Coal:—This horizon lies 12 to 16 fms. below the Crofthead Slatyband Ironstone position. In some localities, as at Bowhousebog, a thick, but very foul coal is associated with the fireclays, but generally this coal is thin or even wanting: the fireclays, however, are fairly persistent and appear in bores at many widely separated localities. Thicknesses of 6 to 8 ft. are frequently recorded and there are often other workable seams not far below.

(2) Nine or ten fathoms above the Curdly Ironstone and Limestone:—This is a well-marked horizon, easily recognised by the occurrence of a very persistent thin marine limestone or limy cement. Some 9 fms. higher in the sequence there is a very constant horizon marked by thick fireclays and fireclay blaes often containing balls of clayband ironstone. It may be several fathoms thick and seems to be particularly well developed in the Murdostoun district.

(3) Associated with the Curdly Ironstone position:—Here again fireclays of workable thickness often occur. A clay from this horizon at Levenseat has been tried for the manufacture of firebricks, but to no great extent.

Many other seams have been met with at different horizons, but these are more local. No search for fireclays should be made without as full a knowledge as possible of the local sequence with its thickness and index horizons, such as the Slatyband Ironstone, the Curdly Ironstone and Cement Limestone, and the Castlereay Limestone.

Coal Measure Fireclays.

CAMPBELL & Co.

Falkirk.

Roughcastle Mine.

At Roughcastle (p. 219) two higher seams, at the base of the Coal Measures, are also wrought. These are:—

(1) A fireclay immediately overlying the Slatyband Ironstone. The section here shows:—

FIRECLAY	...	...	...	...	...	...	Ft.	In.
Coal	...	...	...	...	...	...	5	0
							0	8

Wrought by day-level.

In the workings the coal has sometimes a top rib of blackband ironstone. The ironstone is 0 to 6 in. thick, but occasionally reaches 18 in. in "lunkers." From the evidence available it is probable that the coal and ironstone represent the horizon of the Crofthead Slatyband, which is regarded as the base of the Coal Measures; the seam was formerly mined by the Carron Iron Co. in the Roughcastle area for ironstone, and must have been locally of much better quality than the recent fireclay workings indicate.

This clay is used chiefly for mixing with the ganister in the manufacture of firebricks.

(2) A "ganister" associated with the Bonnyhill Craw Coal.

The section shows:—

Coal	...	...	...	...	...	...	...	In. 20-22
GANISTER OR FIRECLAY	...	...	...	...	...	...	...	18

This seam is a strong, firm, somewhat sandy fireclay, passing locally into a good ganister closely resembling the ganisters of the Bonnybridge horizon.

It is largely sold, both in the dry and wet ground states, to steel works.

The Bonnyhill Craw Coal lies about 5 fms. above the Slatyband fireclay, and may possibly represent the horizon of the Armadale Slatyband.

CARRON COMPANY.

Carron, Stirlingshire.

Carronhall Colliery.

Maps: One-inch Ordnance and Geological 31; six-inch Stirling 24 S.E.

Latitude $56^{\circ} 1' 50''$. Longitude $3^{\circ} 46' 25''$.

A small amount of fireclay is raised along with the Craw and Coxrod Coals at Carronhall and used at Carron in the manufacture of firebricks. About 2,400 tons were raised in the year 1915.

CALLENDAR COAL COMPANY, LTD.

Falkirk.

Maps: One-inch Ordnance and Geological 31; six-inch Stirling 30 N.E.

Latitude $55^{\circ} 58' 56''$. Longitude $3^{\circ} 45' 26''$.

At the new pit, $1\frac{1}{2}$ miles S.E. of Falkirk, the Callendar Coal Co., are working a fireclay in the position of the Armadale Ball Coal.

The fireclay is 6 ft. thick, and is raised from a depth of 40 fms.

The clay is used at the Callendar brickworks, Glen, 1 mile west of the new shaft, in the manufacture of firebricks and blocks, grate and stove backs, pipes, etc.

There is a large field of this clay.

CHAPEL COAL COMPANY, LTD.

Morningside Brickworks, Newmains.

Situation : Near Morningside Station.*Maps* : One-inch Ordnance and Geological 23; six-inch Lanark 19 N.W.Latitude $55^{\circ} 46' 42''$. Longitude $3^{\circ} 51' 52''$.*Geological formation* : Coal Measures.

The fireclay used here is the floor of the Lower Drumgray Coal,¹ and is brought by rail a distance of about a mile from the Company's Chapel and Hyndshaw Pits.

The section of the seam shows:—

								Ft.	In.
Blacs	...	...	...	...	...	...	...	1	6
Coal	...	...	...	...	...	...	...	2	6
FIRECLAY, variable	...	...	...	...	...	...	...	between 2 and 3	0

The clay as raised is grey, rooty and fairly hard; it burns a white colour and provides excellent material for making refractory bricks. It is ground at the works; the bricks are hand-moulded, dried and burnt in coal-fired Newcastle kilns. The contraction is low, being only $\frac{3}{4}$ of an inch. This clay seems specially adapted for difficult shapes, and a large trade in these is done. For some of these the ground clay is mixed with ground 'grog' (burnt bricks), and a proportion of a ground clayey sandstone from the Fauldhouse district.

Reserves : If the quality of the clay holds good throughout the field, there are ample reserves in view.

¹ This seam is the equivalent of the Shotts Low Coal and should be more correctly termed the Mid Drumgray.

CHAPTER XVII.

SCOTLAND—(Continued).

RENFREWSHIRE.

Fireclays of the Calciferous Sandstone Series.

R. BROWN & SONS, LTD.

Ferguslie Fireclay Works, Paisley.

Maps: One-inch Ordnance and Geological 30; six-inch Renfrew 12 N.W.

Latitude 55° 50' 28".

Longitude 4° 27' 23".

Geological formation: Calciferous Sandstone Series.

The following general section shows the position of the Ferguslie seam in the Calciferous Sandstone sequence near Paisley.

					Fms.	Ft.	In.
Hurlet Limestone	...	...	...	...	27	4	0
Strata, about	...	...	...	...	1	0	0
Hollybush Limestone	...	...	...	...	0	1	0
Coal	...	...	...	...	5	0	0
Strata	...	...	...	...	0	2	0
Sandholes Coal	...	...	...	...	20	0	0
Dykebar Marls	...	...	...	...	1	0	0
FERGUSLIE FIRECLAY	...	...	...	...	3	0	0
Strata	...	...	...	...	0	2	0
Dykebar Limestone	...	...	...	...	0	1	0
Coal, very foul	...	...	...	...	10	0	0
Strata	...	...	...	...	0	3	0
Castlehead Upper Coal	...	...	...	...

This seam was worked from a shaft situated close to the works up to the year 1905, cessation being due to exhaustion of the original holdings. The shaft was 15 fms. deep, and the section of the workings showed:—

					Ft.	In.
Main Seam ...	{	Sandstone ...	...	...	10	0
		FIRECLAY ...	...	...	3	9
		Coal ...	...	...	0	6
		FIRECLAY ...	...	...	3	6
		Sandstone ...	...	...	6-12	0
Lower FIRECLAY (very slightly worked).						

The main fireclay was of excellent quality and was used for the best sanitary ware.

The same firm worked the Newton Pit situated about 1 mile south of Ferguslie Fireclay Works and just west of the "Chain Road." The Newton Coal¹ was wrought here at 30 fms., but the shaft was sunk to 33 fms. 5 ft. in order to work a seam of fireclay about 2 fms. under the coal. Almost immediately north of

¹ About 105 fms. below the Hurlet Limestone.

Newton Pit, the Newton fault was met with; this fault runs east and west and has a downthrow to the north of 55 fms. A mine driven through the fault struck a fireclay on the downthrow side. This fireclay showed:—

						In.
FIRECLAY	...	...	...	...	...	27-48
Stone	...	...	...	...	...	13-16
FIRECLAY	...	...	...	...	...	20-60
Stone	...	...	...	...	...	12-30
FIRECLAY	...	...	...	...	...	12-14

The Newton Pit is now abandoned and it is proposed to sink a shaft on the north side of the fault.

At present the fireclay heaps and bings at the two abandoned pits are being used.

Reserves: There is no lack of fireclay at these works for their special manufactures.

SPEIRS, GIBB & Co.

Caledonia Fireclay Works, Paisley.

Caledonia Pit.

Maps: One-inch Ordnance and Geological 31; six-inch Renfrew 12 N.W.

Latitude 55° 51' 15". Longitude 4° 26' 4".

This pit was closed in 1914.

Geological formation: Calciferous Sandstone Series.

A few fathoms below the surface occurred:—

						Ft. In.
Hollybush	{	Limestone	...	...	...	4 1
Limestone	{	Blaes	...	...	...	0 6
		Limestone	...	...	...	2 0
		Hard coaly slate	...	...	...	1 6
	{	Soft coal	...	...	...	1 0
		FIRECLAY	...	...	...	5 4
		Sandstone	...	...	...	—

The coal, though poor, was worked along with the fireclay.

At a depth of 30 fms. in the shaft the following fireclay was wrought:—

						Pt. In.
		Sandstone roof	...	...	...	—
Mid Seam	{	FIRECLAY	...	...	...	5 0
or Ferguslie		Stone	...	...	...	1-2 6
Main.	{	FIRECLAY	...	...	...	5 0
		Sandstone pavement	...	...	...	—

The clay was rather irregular in thickness and by no means of such good quality as at Ferguslie.

At 62 fms. occurred the Castlehead Lower Coal, lying between two beds of fireclay, both of which were worked.

No less than five seams have been wrought at various horizons below the Hollybush Limestone.¹

¹ For more details see 'Economic Geology of the Central Coalfield, Area iv. (Mem. Geol. Surv.), 1920, pp. 5-15.

Potential Resources.

Fireclays are abundant in the Calciferous sediments.

As regards the unproved areas of the Ferguslie Clay the most promising is probably the broad stretch of Calciferous rocks between Dykebarhill, Barrhead and Hurlet: the clay will certainly occur here and at no great depth, but of its quality nothing is known. The fireclay seen in the banks of the stream in the plantation north of Dykebar Station must represent the Ferguslie Seam or one very close to it.

In addition, there should be other clays between the Hollybush and Hurlet Limestones; the strata are gently inclined and relatively free from faults. The district is crossed by two railways.

Fireclay in the Carboniferous Limestone Series.

ALLAN KIRKWOOD, LTD.

Darnley Fireclay Works.

Situation: About 1 mile east of Barrhead.

Maps: One-inch Ordnance and Geological 30; six-inch Renfrew 12 S.E.

Latitude 55° 47' 50". Longitude 4° 21' 20".

The seam, which is very local, is associated with the two thin Arden Coals, which occur just under the Calmy Limestone in the district to the east of Barrhead.

The section is:—

							Ft.	In.
Foul Coal (Upper Arden)	...	...	...	...	...	...	1	0
Blaes	...	...	...	...	...	...	0	6
FIRECLAY	...	...	...	...	...	...	2	0
Lower Arden Coal and coaly blaes	...	...	...	...	...	...	2	0
FIRECLAY	...	...	...	...	...	...	4	6

Both the layers of fireclay are used, but the lower is rather the better in quality. The two are mixed in varying proportions, and used in the manufacture of firebricks, pipes and sanitary ware. Neither coal is here of any value.

CHAPTER XVIII.

SCOTLAND—(*Continued*).

AYRSHIRE, ARRAN AND WIGTOWNSHIRE.

Millstone Grit Fireclays.

The general sequence of the Millstone Grit Series in North Ayrshire is as follows:—

COAL MEASURES: Raise Coal		9 in. to 3 ft.
MILLSTONE GRIT	{ Ayrshire Bauxitic Clay	6 to 24 ft.
	{ A series of lava flows with inter-bedded foul coals, fireclays and ganisters	6 to 40 fms.
	{ Monkcastle Clay	10 to 20 ft.
	{ Sandstone ... ..(about)	20 ft.

The working of the North Ayrshire fireclays is only a recent development, but is likely to become an increasing and important industry. The names given above have been adopted for the clays of the two horizons: the Monkcastle Clay from the place where it was first wrought; the Ayrshire Bauxitic Clay from the county in which it attains its greatest development, and from the probable origin of this clay being similar to that of some bauxites.

The *Monkcastle Clay* appears to be widespread in North Ayrshire, but is locally absent or thin. It is well seen on the south side of the Caaf Water, $\frac{1}{4}$ mile below Drumstee Mill to the west of Dalry. It was also exposed in the cutting on the Caledonian Railway Line about 100 yards east of Salcoats Station. A seven-foot seam of clay on the same horizon has been recorded by the late Dr. Clough from the north-west side of the Fenwick Water due south of Meiklewood near Kilmarnock. The seam has also been met with in two bores, both of which are situated in the six-inch sheet Ayrshire 11 S.E.

Name of bore and locality.	Thickness of seam. Ft.	Depth from surface. Fms.
Thompson's Coal Pit, Smithstone, 2 miles N.W. of Kilwinning	9	31
Redston Farm, $\frac{1}{4}$ mile N.E. of Kilwinning...	7	42

At present the Monkcastle clay is mined and worked at only one locality.

THE DOUGLAS FIREBRICK CO. AND MORGAN CRUCIBLE CO.

Kilwinning.

Monkcastle Mine.

Works: Situated on the side of the Glasgow and South Western line to Glasgow, about $\frac{1}{2}$ mile south of Dalry Station.

Mine: Situated $\frac{1}{2}$ mile from the works.

Maps: One-inch Ordnance and Geological 22; six-inch Ayrshire 11 N.E.

Latitude $55^{\circ} 41' 35''$. Longitude $4^{\circ} 43' 16''$.

Geological formation: Millstone Grit, Monkcastle Clay.

The section exposed at the mine is as follows:—

	Ft.	In.
Soft crumbly black clay of good quality	2	6
Hard shaley clay with carbonaceous matter and a little iron pyrites	1	6
Hard grey clay with columnar vertical jointing	3	6
Grey clay not jointed	2	3

The clay is of good refractory quality, averaging Seger cones 33-35, the upper part of the seam being usually about one cone higher than the lower. As at present worked it is not very plastic, a fault that could no doubt be remedied by prolonged weathering and finer grinding. Arrangements for this purpose are now being made. The upper beds when burnt are distinctly iron-speckled, but in no case is the speckling so bad that hand-picking would not easily produce material suitable for certain uses, such as *grog* for glass-house pots.

The works have only recently been started, and have a capacity of about 10,000 bricks per day.

Reserves: Large.

Potential Sources.

The quality of this clay where worked at Monkcastle is good, but nothing is yet known as to its value at Saltcoats, Smithstone and Redston. Tests made for the late Dr. Clough show that it has deteriorated near Kilmarnock. The particulars of this locality are as follows:—

Fenwick Water.

Maps: One-inch Ordnance and Geological 22; six-inch Ayrshire 18 N.W.

Latitude $55^{\circ} 38' 22''$. Longitude $4^{\circ} 28' 0''$.

A seven-foot seam of greyish-coloured clay is exposed immediately below the base of the Millstone Grit Lava Series on the north bank of the Fenwick Water about 300 yards due south of Meiklewood. Refractory tests made on samples of material taken from the top and bottom portions of the seam gave the following results:—

	Ft.	Cone.
Top portion	4	30-31
Bottom portion	3	26

It is thus seen that while the top is only moderately refractory, the bottom is distinctly poor.

In the district between Dalmellington and Lugar the Millstone Grit Series is from 70 to 80 fms. in thickness and consists mainly of sandstones, fakes and blaes with a few thin coal seams. No interbedded contemporaneous igneous rocks similar to those in North Ayrshire have so far been met with, but numerous intrusive sheets of dolerite occur.

The sequence here is quite unlike that of North Ayrshire, and consequently no correlation of the fireclay horizons is possible.

Up to the present time little attention has been paid to the fireclays of this district: the one existing mine is only worked intermittently for special purposes.

DALMELLINGTON IRON CO., LTD.

Dunaskine Mine.

Situation: The works are situated on the sides of the burn south of Corbie Craigs, and east of Dunaskine.

Maps: One-inch Ordnance and Geological 14; six-inch Ayrshire 46 N.E.

Latitude 55° 20' 55". Longitude 4° 26' 35".

Geological formation: The geological position of the seam is about 50 fms. below the Burnfoot Blackband Ironstone, and 20 fms. above the top limestone of the district. It seems probable, therefore, that the clay is of Millstone Grit age.

The section of the seam is as follows:—

		Ft. In.	
DUNASKINE FIRECLAY.	Blaes and ironstone balls	7	10
	Fireclay blaes	11	0
	Coal	1	4
	Fireclay blaes	5	6
	Coal	0	10
	Fireclay blaes	4	2

The clay is worked by a mine; about 70,000 tons are raised every 4 or 5 years and made up into furnace blocks, bricks, etc., for the use of the Company only.

Ayrshire Bauxitic Clay.—In the northern part of the Ayrshire Coalfield the Millstone Grit consists mainly of a series of highly decomposed basic lava-flows. The thickness of the sequence and the number of flows vary considerably, but at all the exposures so far examined the top flows pass insensibly up into a peculiar hard aluminous rock, which is well jointed, possesses a conchoidal fracture and varies in colour near the base from dark or light grey to pale buff, while the upper portions of the seam may be quite black. The origin of the clay is in many respects similar to that of bauxite, but while in that mineral the alumina is in a soluble form as hydrate, in the Saltcoats material only a small percentage of alumina is soluble, the remainder being in some form (probably a silicate or mixture of silicates) which is insoluble in hydrochloric acid.

Extent of the seam.—The outcrop has been traced by Mr. E. M. Anderson from South Bay, Saltcoats, as far as Kilwinning, and small outliers have been detected near Lochwood and Smithstone, 2 miles north-west of the same town. Several exposures occur farther to the east on the banks of the Lugton Water, $\frac{1}{2}$ mile east of Sevenacres Mains, and also in the plantation 300 yards south of Caven Mill. From here the crop swings south, and the seam is well exposed on the left bank of the Annick Water 500 yards E.S.E. of Fairliecrevock. Farther again to the east the outcrop of the bed was noted by the late Dr. Clough in the banks of the Fenwick Water 500 yards south by east of Southcraig, and about 2 miles north-east of Kilmarnock.

A seam of similar nature and on what is probably the same

horizon, has been observed by Mr. Macgregor on the Kello Water, about $\frac{1}{2}$ mile above Kello Bridge, between Kirkconnel and Sanquhar, and a clay of the same type was noted some 30 years ago by Messrs. Peach and Macconochie on the Low Knockglass Burn about $1\frac{3}{4}$ miles S.W. of Stranraer. At neither of these localities is the clay associated with underlying igneous rocks, but in the Island of Arran a bauxitic clay like that of Saltcoats rests upon a decomposed lava-flow. The general account given

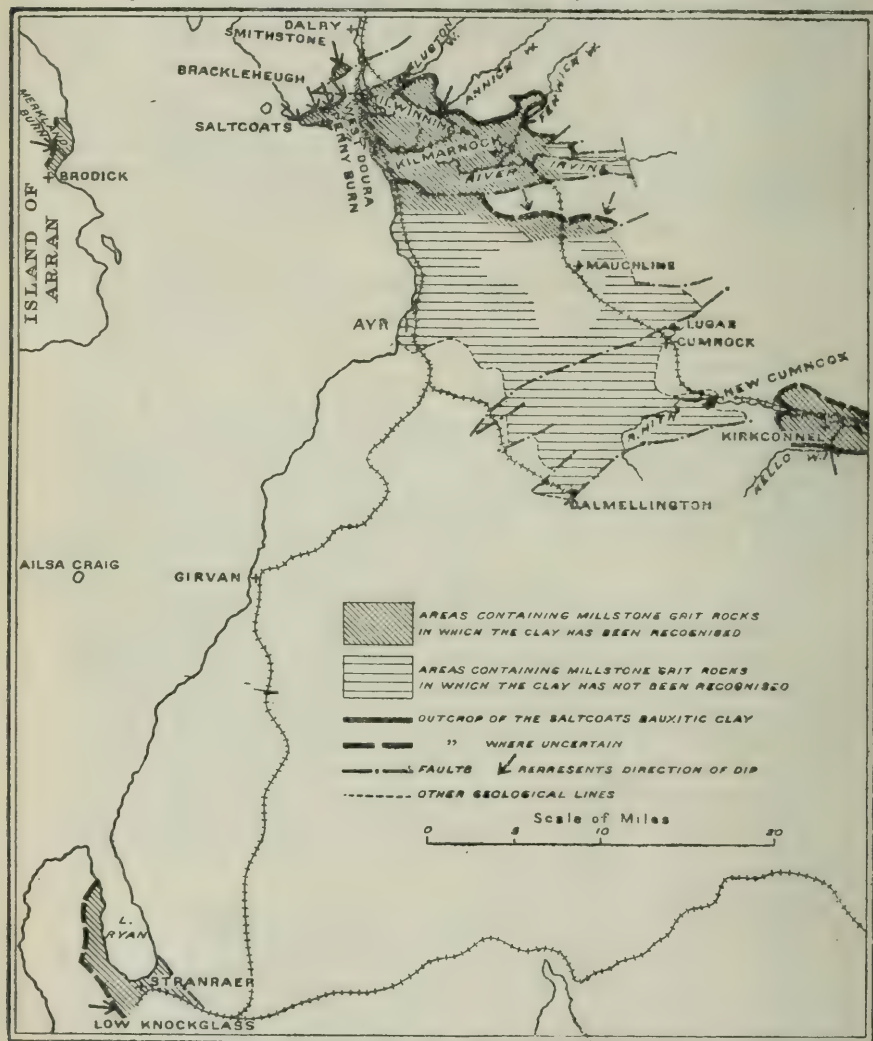


FIG. 13.—Map showing the outcrop and extent of the Ayrshire Bauxitic Clay.

above shows that the bauxitic clay extends over a wide area, and probably underlies the whole of the Ayrshire coalfield from its northern boundary to the large E.N.E. fault which passes through Dundonald towards Galston and Newmilns. From the evidence so far available it also seems probable that this clay is always

present in those areas where contemporaneous igneous rocks are associated with the Millstone Grit Series.

The seam has also been recognised in material from bores along the southern outcrop of the Millstone Grit lavas about 2 miles south of the above-mentioned fault. The exposures in this area are, however, poor, and those so far visited do not show the top of the volcanic series.

Character and Composition.—The clay presents the following peculiar external characters which are fairly constant over the whole area. The rock is usually grey in colour and exceedingly well-jointed, breaking up into rough cubes. The joint-faces are often covered with thin veins of a white translucent mineral that can be scratched with the finger-nail and has been proved to be kaolin. The clay itself is hard and brittle, with a conchoidal fracture and is absolutely non-plastic, but the broken surfaces can be polished by rubbing with the hand. The grain varies considerably; sometimes it is exceedingly fine, elsewhere numerous small oolitic grains are embedded in a fine grained groundmass, while in other cases it is distinctly coarse and the rock full of angular fragments, giving it the appearance of a volcanic tuff. The upper layers often contain rootlets. In some instances there are bands of a black colour which have almost the appearance of a blackband ironstone, but are much softer and show a beautiful velvet lustre on newly-fractured surfaces. In chemical composition the clay is peculiar. It often contains alumina in a form which is soluble in acid, and also in some cases far more than is needed to satisfy the demands of the kaolin molecule. The chemical state in which this excess alumina exists is not yet known, since it is not all in a soluble form. It is probably present partly as gibbsite, partly as a mineral approximating to diasporé in composition. Free silica is absent or rare, and is most likely united with alumina in the form of kaolin. The clay is often rich in titanium, usually present as rutile, as much as 14 per cent. of titanic oxide having been found in material from one locality.

The amount of alumina present varies considerably, but on the whole is unusually high. So far as is known the clay from near Saltoats is by far the richest in alumina, and at the same time is the most refractory. The following table gives the percentage of alumina in samples of clay taken from various localities, also the Seger cone tests of materials:—

	Saltoats Shore.	Saltoats Quarry.	Brack- leugh.	Lugton Water.	Annick Water.	Fenwick Water.	Sanguhar.	Stranraer.	Arran.
Al ₂ O ₃ ...	45-50	38-52	36-39	35	35-40	30-40	26-34	39	32-34
Seger cone ¹ ...	Over 35	36-37	35	30-31	29	30-31	—	—	—

¹ For the bulk of these we are indebted to W. Douglas, Esq., of the Douglas Firebrick Co., Kilwinning.

Origin.—The association of this clay with decomposing igneous rocks and beds of ironstone suggests that the deposit owes its origin to agencies which, in many respects, are similar to those responsible for the formation of bauxite.

In many localities the underlying decomposing igneous rock can be seen passing insensibly up into the clay, showing that the latter is a direct decomposition-product of the former.

The upper part of the clay may be full of rootlets and rest directly beneath a coal seam, which is itself overlain by a similar type of clay and this again by another coal seam.

The bauxitic character of this clay was first recognised during the revision of the area by the Geological Survey when attention was drawn to the peculiar nature of the rock and the high alumina content of two samples analysed. One of these analyses, of a sample collected by Mr. E. M. Anderson from the Saltcoats shore, was communicated to Mr. W. Douglas of Kilwinning, who submitted further samples to Dr. Mellor of Stoke-on-Trent for refractory tests. The result exceeded all expectations, giving above Seger cone 35.

The exploitation of this seam for refractory purposes is only a recent development. At the present time, however, larger operations are in view, and a considerable area of the seam in the Saltcoats district has been leased, and bricks of excellent quality are now being made.

SCOTSWOOD FURNACE CO.

Newcastle-on-Tyne.

Saltcoats Glebe Quarry.

Situation: About 1 mile N.E. of Saltcoats.

Maps: One-inch Ordnance and Geological 22; six-inch Ayrshire 16 N.W.

Latitude $55^{\circ} 38' 15''$. Longitude $4^{\circ} 47' 30''$.

The quarry is situated in the field behind the new Parish Church, and is about 300 yards by road from the Caledonian Railway Station.

The section now exposed is as follows:—

	Ft.	In.
Raise Coal	3	0
Fine grained grey clay with rootlets	2	6
Dirty coal	2	0
Black clay	2	3
Hard grey clay with angular fragments (like a volcanic ash)	1	6
Black clay	0	4
Fine-grained grey clay with rootlets	1	4
Hard grey oolitic clay	1	3

The hard grey oolitic clay is the best quality, but is absolutely non-plastic; being very free from iron it shows no speckling when burnt. The fine-grained grey clay is not so refractory as the oolitic and angular grained clays, but is of a rather mild character and if sufficiently finely ground should become quite plastic.

The black clay contains a fair percentage of carbonaceous matter and is rather more apt to be contaminated with iron pyrites than the other varieties. It shrinks somewhat badly on burning

and assumes a greenish-white porcelain-like appearance. When finely ground it becomes quite plastic.

At the present time the clay is sent by rail to Newcastle, but works are to be erected on the spot. The clay is ground and mixed with a certain amount of plastic clay as a bond and supplies the highest class refractory ware such as furnace nozzles, electric furnaces, steel and brass furnaces, etc.

Saltcoats Shore.

The seam is well seen on the shore about $\frac{1}{4}$ mile south-west of the above-mentioned quarry. About 5 or 6 ft. is exposed; the bottom part is pink in colour, full of small specks of carbonate of iron, and passes down into decomposing volcanic rock. The upper 3 ft. or so is, however, free from such specks, grey in colour, distinctly oolitic, and contains rootlets. The first bricks made from the clay were of material from this locality.

Brakeplough or Brackleheugh Quarry.

Maps: One-inch Ordnance and Geological 22; six-inch Ayrshire 16 N.W.

Latitude $55^{\circ} 38' 40''$. Longitude $4^{\circ} 45' 30''$.

The exposures occur on the banks of a small burn on the west side of the road $\frac{1}{4}$ mile north of Stevenston. The seam is about 9 ft. thick, and varies in colour from dark grey to almost white. The area is much broken up by faulting, but during the summer of 1917 the available material was removed by open-cast working.

DOUGLAS FIREBRICK CO. AND MORGAN CRUCIBLE CO.

Smithstone and Lochwood.

Maps: One-inch Ordnance and Geological 22; six-inch Ayrshire 11 S.E.

Latitude $55^{\circ} 40' 30''$. Longitude $4^{\circ} 43' 35''$.

Several exposures can be seen on the road sides $\frac{1}{4}$ and $\frac{1}{2}$ mile south-east of Outer Smithstone, and about two miles by road from Kilwinning.

The deposit at Smithstone lies in a small basin of about a twelfth of a square mile in extent. Over this area the seam averages 24 ft. in thickness and consists of a large number of beds of varying composition. Much of the material is of an ashy fragmental nature, but the other bands are exceedingly fine-grained and white or black in colour. At the present time this area is being opened up with a view to working the beds of high quality material.

At Lochwood, about one mile to the south-west the seam is seen to be about 20 ft. in thickness, and to consist of very similar materials to those found at Smithstone.

LEEDS FIRECLAY CO., LTD.

West Doura.

Maps: One-inch Ordnance and Geological 22; six-inch Ayrshire 16 N.E.

Latitude $55^{\circ} 39' 0''$. Longitude $4^{\circ} 43' 0''$.

A small quarry has been opened on the farm of West Doura about $\frac{1}{2}$ mile south-west of the Glasgow and South Western Rail-

way Station at Kilwinning. About 3 to 4 ft. of clay is seen. It has a dark-grey, streaked appearance, and the cracks and joint-faces are often badly ironstained.

Dubbs.

Maps: One-inch Ordnance and Geological 22; six-inch Ayrshire 16 N.E.

A quarry has recently been opened up on the farm of Dubbs about three-quarters of a mile S.S.W. of West Doura Quarry. The face shows about 14 ft. of clay, which is of fairly good quality, and is being used for the manufacture of alum.

Potential Sources.

Penny Burn.

Maps: One-inch Ordnance and Geological 22; six-inch Ayrshire 16 N.E.

An exposure of the top of the seam can be seen in the bottom of the Penny Burn $\frac{3}{4}$ mile S.S.W. of West Doura.

Caledonian Railway Cutting, Kilwinning.

Maps: One-inch Ordnance and Geological 22; six-inch Ayrshire 16 N.E.

A section in the cutting on the Ardrossan branch of the Caledonian Railway, about 150-200 yards west of Kilwinning Station, shows from 5 to 6 ft. of dark-grey, oolitic clay resting on light green, decomposed volcanic rock full of specks of carbonate of iron.

Lugton Water.

Maps: One-inch Ordnance and Geological 22; six-inch Ayrshire 12 S.W.

Latitude $55^{\circ} 40' 0''$. Longitude $4^{\circ} 38' 40''$.

Several exposures occur on the banks of the Lugton Water, $\frac{1}{2}$ mile east of Sevenacres Mains, and also on the south side of the river near Caven Mill.

The seam is about 6 ft. thick and rests directly upon a decomposed lava-flow. The base is pale grey and weathers spheroidally. The upper portion is pale buff-coloured and very homogeneous. The burnt clay has a deep yellowish brown colour.

Annick Water.

Maps: One-inch Ordnance and Geological 22: six-inch Ayrshire 17 S.E.

Latitude $55^{\circ} 38' 48''$. Longitude $4^{\circ} 35' 20''$.

The following section is seen on the left bank of the Annick Water about 500 yards E.S.E. of Fairliecrevock:—

	Ft.	In.
Hard white clay	3	0
Ironstone rib (? decomposed lava)	2	6
Hard white clay	2	3
Black speckled clay passing down into red and grey-speckled clay rock (volcanic ash)	1	2
Irony rib	0	2
Hard white clay	2	6
passing down gradually into decomposed lava.		

The exposure is situated about 1 mile by road from Cunningham-head Station.

Fenwick Water.

Maps: One-inch Ordnance and Geological 22; six-inch Ayrshire 18 N.W.

Latitude $55^{\circ} 38' 0''$. Longitude $4^{\circ} 28' 30''$.

Several exposures of the bauxitic clay are to be seen on the sides of the Fenwick Water between Borland Bridge and Rowallan Creamery near Kilmarnock. The sections illustrate very well the extremely variable nature of the deposit which here ranges in thickness from a few inches to 8 or 9 ft., and at one locality is even totally absent.

Merkland Burn, Island of Arran.

Maps: One-inch Ordnance and Geological 21; six-inch Ordnance only, Argyll and Bute 244 N.E. The geological MS. map can be consulted at the Edinburgh Office.

The peculiar hard bauxitic fireclay of Ayrshire has recently been found to occur in Arran, where it is well seen in the sides of the Merkland Burn.

Latitude $55^{\circ} 36' 15''$. Longitude $5^{\circ} 8' 45''$.

The exposure is situated about $\frac{1}{2}$ mile up the stream from the road, and can easily be reached by following the old path up the north side of the burn. The section shows about 5 to 6 ft. of pale pink, hard, fireclay with occasional red iron patches, resting directly on a highly decomposed ferruginous lava-flow. The refractory quality of the Arran clay is not so high as that found near Saltcoats and Stevenston in Ayrshire. Its presence is, however, interesting as showing the wide extent of this peculiar fireclay at a definite geological horizon.

WIGTOWNSHIRE.

Low Knockglass.

Maps: One-inch Ordnance and Geological 3; six-inch Wigtownshire 16 N.W., S.W.

Latitude $54^{\circ} 53' 0''$. Longitude $5^{\circ} 2' 50''$.

A narrow strip of Carboniferous rock occurs on the west side of Loch Ryan, and has been traced from Clachan Heughs to Low Knockglass. The total thickness of the beds exposed is only about 100 ft: they rest unconformably on Silurian slates and are covered again unconformably by Permian brockrams. The beds are mainly of a sandy nature and near Meikle Mark a few Lower Coal Measure plants have been found. No representatives of the Carboniferous Limestone Series occur, and as the plants were obtained from the highest part of the series exposed, it seems likely that the lower portion is of Millstone Grit age.

A section on the west side of Low Knockglass Burn shows about 3 ft. of a hard, pink, buff- or purple-coloured fireclay of the same type as the Saltcoats Bauxitic Clay. It rests on a speckled sandstone, but the top is not seen. The dip of the beds is about 25°

to the east, under the Permian rocks, and as this is the only exposure, a certain amount of boring would be necessary to prove the extent of the seam. The clay contains about 39 per cent. of alumina and may be worthy of attention.

The exposure is situated about $1\frac{3}{4}$ miles south-west of Stranraer Harbour, and about 1 mile north of the Port Patrick railway.

Coal Measure Fireclays.

The seat-earths of several coal seams in the Coal Measures are worked on an extensive scale near Kilmarnock, mainly for the manufacture of sanitary ware, enamelled, vitrified and ordinary building-bricks; also for ordinary firebricks on a small scale.

The clays beneath the 'Ladyha,' Wee and Darroch Coals are worked by Messrs. J. and R. Howie, Ltd., of Crosshouse and Hurlford, and by the Southook Fireclay Co., of Southook and Bonnyton, Kilmarnock.

The Bourtree Hill Coal Co., Dreghorn, work the clays beneath the Turf, Wee, 'Ladyha' and Stone Coals. The clay underlying the Wee Coal is considered the best.

Messrs. J. & M. Craig, Ltd., Kilmarnock, have worked the clays beneath the Darroch, Turf, Wee, Oil-shale and 'Ladyha' seams.

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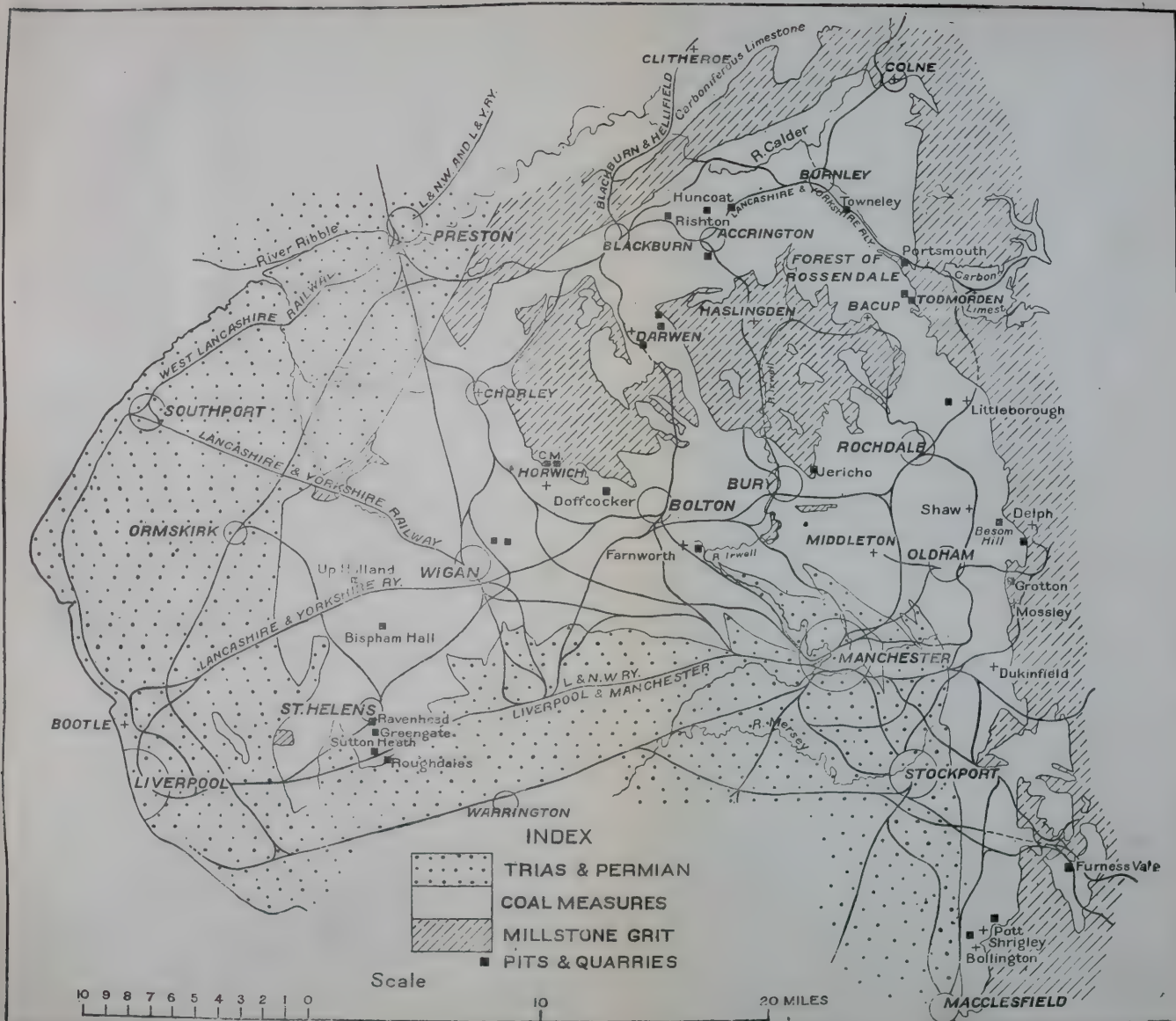
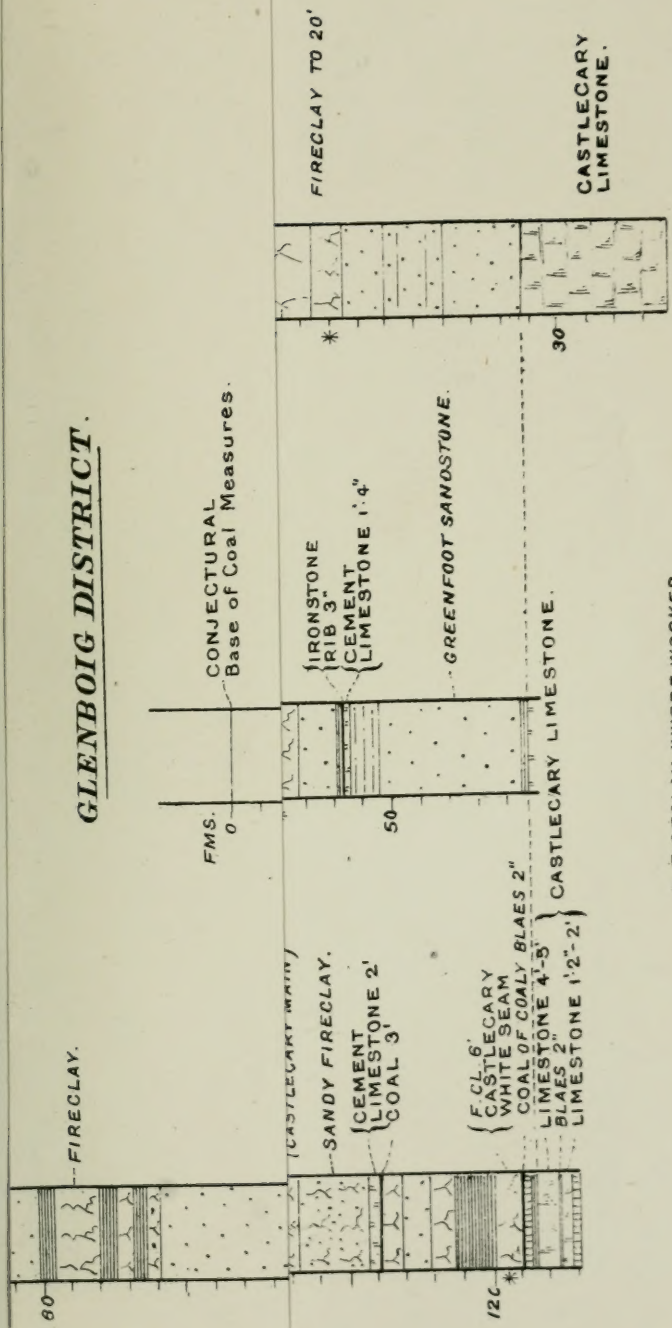


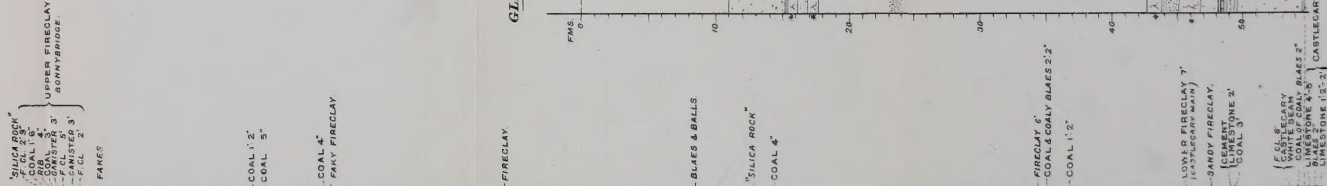
Plate III. Map of South Lancashire and part of East Cheshire.

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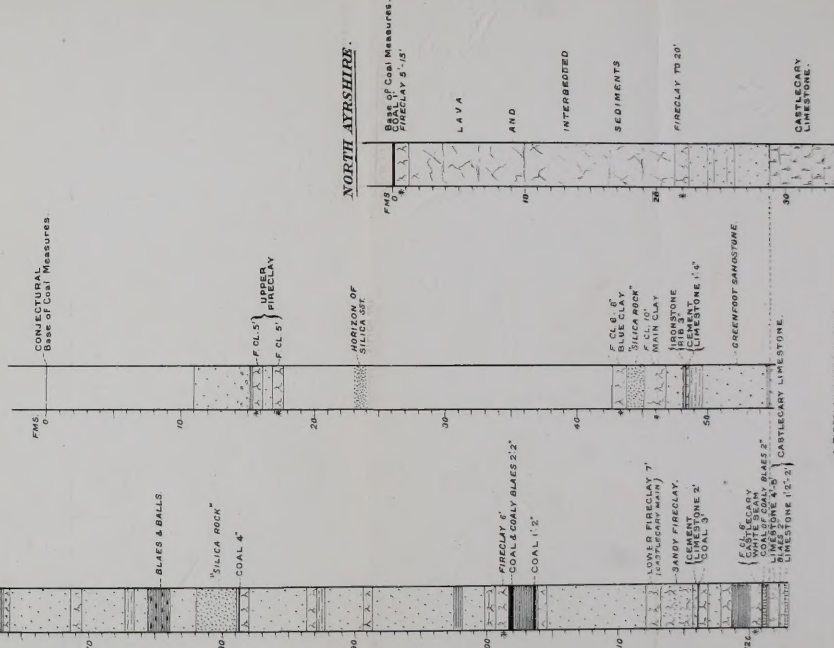


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VERTICAL SECTIONS
OF
MILLSTONE GRIT.
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